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THE

AMERICAN TEXT-BOOK

OF

PROSTHETIC DENTISTRY.

IN CONTRIBUTIONS BY EMINENT AUTHORITIES.

EDITED BY

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WITH THE

CORDIAL CONSENT OF THE CONTRIBUTORS

THIS VOLUME IS DEDICATED TO

EDWARD CAMERON KIRK, D.D.S., Sc.D.,

IN RECOGNITION OF HIS EMINENCE IN DENTAL LITERATURE
SCIENCE, AND EDUCATION

AND AS A

MODEST TOKEN OF THE REGARD OF HIS FRIEND AND COLLEAGUE

THE EDITOR.

PREFACE TO FOURTH EDITION.

THE editor offers a new edition of the *American Text-book of Prosthetic Dentistry* in the hope that it may continue to fill the important place accorded it for so long a time by the teachers, students, and practitioners of dentistry in this country. Being intermediate in character between the hand-book, which is intended to furnish the main facts upon a subject briefly and succinctly, and the work of reference, which as a final authority must give an exhaustive treatise upon its topic, the book is primarily designed as a teaching volume. It stands for and adheres to the general pedagogical principle that a thorough knowledge of the fundamental principles of the subject must first be inculcated, so that the student may attack his problems by the analytical method instead of by rote or authority. After this foundational knowledge is obtained, the technical procedures necessary to construct the various appliances employed in prosthetic dentistry may be undertaken, instead of making the latter first in time and importance—a point of view not in vogue when prosthetic teaching was conducted empirically in the dental laboratory. That this method has been in accord with the present pedagogical practice is attested by the fact of the widespread adoption of the book as a text-book in the colleges of this country.

To the dental practitioner it is hoped the technical teaching will appeal as being an exposition of the most recent approved methods of prosthetic practice. The plan of composite authorship permits the selection of men who have given special attention to the several subjects of which they treat.

Since the appearance of the last edition in no field of dentistry has more gratifying progress been made than in the increase of our knowledge upon the subject of the so-called "anatomical articulation" of artificial teeth. A broader knowledge of the natural masticating mechanism, greater accuracy in the articulators serving to represent a part of this mechanism, and vast improvements by the manufacturers in the designs of artificial teeth themselves have resulted from the activities of various ones concerned in treating this general problem. These facts have necessitated an enlargement of the text upon these several topics in order that it may embrace such details of these subjects as seem to be proved and established. While in none of them has the "ultima thule" been reached, there is a great general improvement in the scientific accuracy of our knowledge of the whole question.

The chapter on *Cast Metal Dentures*, written by the late Dr. Clark L. Goddard, has not been replaced by a new one upon the subject. Since the extensive employment in dentistry within the past few years of the principle of casting metals under pressure, the use of the precious

metals for base-plates by this plan has proved universally disappointing, and none of the technic so far evolved can be recommended to the practitioner or student. The percentage of shrinkage and warpage of the metal when cast in large masses, its lower density and poorer texture than the swaged plate, and the general lack of uniformity of results have all proved obstacles to those who demand accuracy in the finished product. While the methods of casting aluminum and the base metal alloys have all undergone improvement, it is not felt that anything authoritative can be given on this topic at this stage of its development. It is believed that many of the defects of this method that held so much of promise to the prosthetic dentist may in time be overcome and its field of usefulness extended.

The technical details of metallurgical operations as regards obtaining the metals from their ores and all others not directly related to the practice of prosthesis in the laboratory have been omitted from the present chapter on the subject. As the workman must know his tools, so must he know the properties of the materials of which his products are wrought, but other details, interesting and important as they are, must be reserved for the separate work on metallurgy.

The chapters originally contributed by Dr. H. H. Burchard on *The Examination of the Mouth*, *The Taking of Impressions*, and *The Making of Plaster Casts*, and revised by the late Dr. J. P. Gray, whose loss by death the staff of contributors has suffered since the last edition appeared, have been replaced by chapters on these subjects by Dr. A. De Witt Gritman. The remaining chapters by Dr. Burchard and those by Dr. Essig have been thoroughly revised.

In acknowledging his indebtedness to the publishers for their unfailing kindness and valuable assistance during the preparation of this volume, the editor especially wishes to express his appreciation of the sympathetic help of Mr. Christian Febiger, with whom he has had the privilege of many conferences in the progress of the work.

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PROSTHETIC DENTISTRY.

CHAPTER I.

THE DENTAL LABORATORY, ITS EQUIPMENT AND ARRANGEMENT.

By Charles J. Essig, M.D., D.D.S.

and

Charles R. Turner, D.D.S., M.D.

THE LABORATORY.

It is highly important that the mechanical laboratory should be suitably arranged and equipped for the purposes to which it is devoted. In planning the dental offices a room should be selected which is appropriate in size and location. It frequently happens that the laboratory is relegated to a room which cannot be used for other purposes, and which answers the requirements of a workshop in no degree. It should be easily accessible from the operating room to facilitate such operations as band-fitting for crowns which are partly performed in both places. From a hundred to a hundred and fifty feet of floor space are necessary for one or two workmen, and an advantage will be gained if the room is situated with its longest side toward the light. The uniformity of illumination afforded by a northern light recommends this exposure where it is obtainable. Ample light should be provided by sufficient window space so that none of the laboratory operations are required to be performed in shadow. Adequate ventilation and strict attention to the demands of sanitation are necessary hygienic requisites which must not be overlooked.

The furniture and appliances should be especially adapted to the needs of the workman, and arranged to facilitate ease and celerity in his manipulations. Every article which is used in the laboratory should have a place provided for it, to which it may be returned when not in service. Systematic care of the tools and instruments and orderliness and cleanliness in the various mechanical procedures should characterize the laboratory work.

The usual equipment of a dental laboratory consists in a suitable work-bench, carefully adapted to the purpose for which it is to be used; a molding box; plaster table and sink; a swaging block and anvil; at least two lathes, one designed especially for the grinding and fitting of

teeth, the other for finishing and polishing only; a mechanical blowpipe table, supplied with gas-burner on the Bunsen principle, of sufficient capacity to allow of the soldering of full dentures.

In addition to these permanent articles of laboratory furniture it will be necessary to provide a suitable furnace for the melting of zinc, lead, and alloys commonly used in making dies and counter-dies, and also another and different one to be used for the occasional melting of gold and silver and in the formation of alloys to be used as solders. Besides these a vulcanizer to be used in vulcanizing dental rubber, porcelain furnaces for the baking of inlays, crowns, and continuous-gum dentures, and for staining teeth, and a gold casting apparatus for casting molten gold are necessary adjuncts to a fully equipped laboratory.

The accessories of soldering, molding rings and flasks, ingot molds, rolling mills, draw-plates, pickling solutions, with the most suitable vessels for holding the same, grinding and polishing materials, fluxes, varnishes, adhesive wax, and bench tools, all necessarily form part of the equipment of the dental laboratory, and will each be described in this chapter or in the chapter devoted to that special subject.

The Work-bench.—The work-bench should be constructed of cherry, ash, or well-seasoned oak; it should be provided with not less than two sets of drawers, one to contain the ordinary bench tools, being arranged in a tier at the right hand side; the other directly in front of the workman and over his lap, and intended for the storing of the materials he is using and the filings and scraps from the same. Such a bench will presently be described.

The height of the work-bench should be about 34 inches, which places the work the proper distance from the eyes when the workman is seated upon a stool of usual height (about 18 inches). Jewelers' benches which have been used for dental work are too high, as they have been designed for operations, which necessitate closer vision. It may be said that the stool upon which the operator sits, his own physique, and the height of the bench should be so correlated that the work is not so close to the workman's eyes as to put a continuous strain upon the accommodation, and yet is clear enough for comfortable vision without his bending over. The bench should be located so that the workman faces the light, and for this reason it should be given the preference in position over any other laboratory furniture. The length, when designed for the convenience of two workmen, should be about 5 feet 6 inches; the width may be 24 inches. The top should be at least 1 inch in thickness, and immediately over the tool drawers should be arranged a rest for convenience in filing and finishing. This rest is usually made of the same hard wood as the top of the bench, 2 inches wide and about 3 inches long, tapering from $1\frac{1}{2}$ inches in thickness where it is mortised into the table to $\frac{1}{2}$ inch at its extremity. It is desirable that the bench be firm and solid to withstand any force exerted upon it in use, and it is advisable in some cases to have it fixed to the wall, especially if it is to be used as a support for the vise in drawing wire. Where it is possible, separate benches should be provided for the several classes of laboratory operations. The tools and materials for each kind of work are then kept together, and a mixing of the scraps and débris of the various operations is prevented.

It is particularly important that a bench or portion of the bench be kept solely for work with the precious metals.

A very convenient and elaborate work-bench of good design is shown in Figs. 1 and 2. It is especially adapted to meet the wants of those who do crown and bridge-work. It is provided with a rolling top, which automatically locks the drawers when closed and yet does not obstruct the light when open. It is provided with a foot-bellows, and drawers for gold solder, plate, wire, files, scrapers, corundum wheels, pliers, cutters, benders, etc.; some of the most complete being shown by Figs. 3, 4, 5, and 6. This bench is a highly finished piece of cabinet work, and would be suitable for the operating room for such work as it is desired to do while the patient is in the chair.

Three benches are shown in Figs. 7, 8, and 9 for vulcanite and gold and general plaster and sand work, respectively. The higher part of Fig. 7 is surmounted by a marble slab, $16\frac{1}{2} \times 14\frac{1}{2}$ inches, for the accommodation of the vulcanizer. Beneath the slab are two drawers 3 inches deep, for flasks, wrenches, and tools used about the vulcanizer. The third drawer contains a series of shallow compartments for the reception of scrapers, etc. The fourth drawer is partially divided by grooved compartments similar to drawer No. 3, and is intended for files, etc. Drawers five and six are for hammers, horn mallets, and other large tools, and for rubber, wax, and other supplies. The cupboard contains a shelf, and will be found convenient.

Adjacent to the series of drawers described above, and under the right-hand end of the lower top, is a cupboard designed for the tooth stock. This cupboard contains a removable case divided horizontally through the centre and of a width to receive the boxes in which teeth are sold, the ends of the boxes projecting beyond the case to allow an easy withdrawal. For convenience the contents of each box may be marked upon its end, and the inner case and its contents may be removed and placed in a safe.

At the left-hand end of the bench are two drawers, one containing a rack into the holes of which the mandrels of the lathe will drop, allowing the grinding wheels to rest upon the surface of the rack and keeping the wheels separated and in place. To the right of this drawer is another drawer of the same size for brush wheels, felt wheels, and cones. Between these last two drawers runs the belt of the lathe.

The lower top of the bench is of hard maple, finished smooth, and a 4-inch rail extends along the back and end.

The filing block is placed in such a location that the workman, when using it, is within easy reach of his tool drawers.

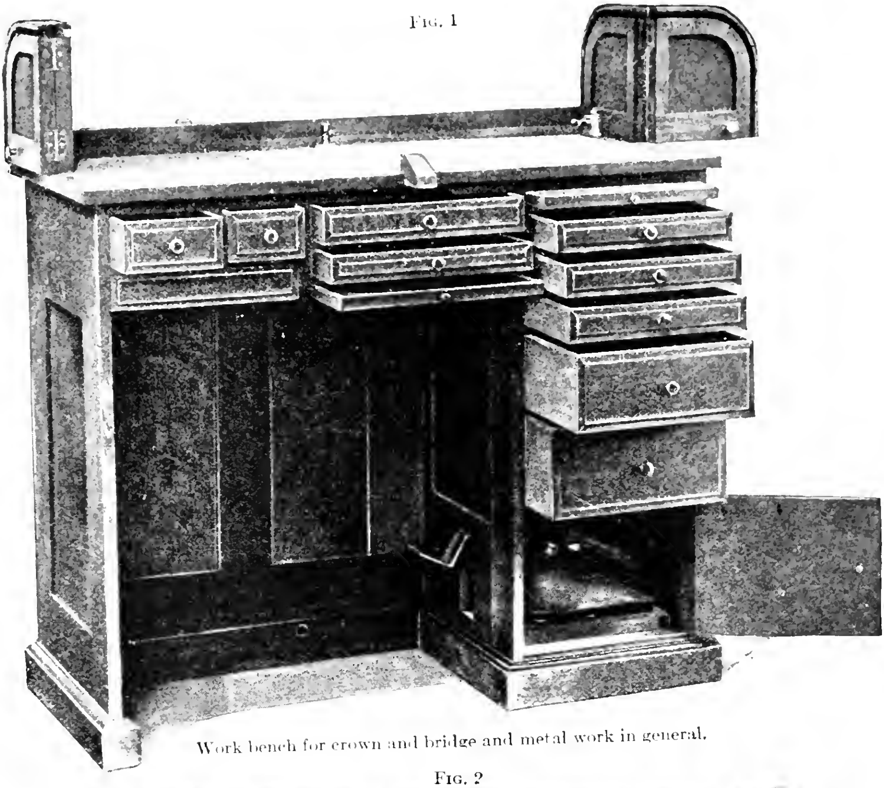
The top of the bench represented by Fig. 8 is a marble slab 16 x 34 inches, and a rail extends around the two ends and back. Under the right-hand end is a slide, and beneath this slide is a drawer arranged with shallow compartments, concave in shape, for files, etc., each compartment being intended for a single instrument.

Beneath this drawer are two drawers containing divisions of suitable size to hold the various plate-cutters, benders, punches, shears, pliers, etc.

Drawers four and five are for bulky tools and supplies.

The lower compartment contains the foot bellows fixed permanently

FIG. 1



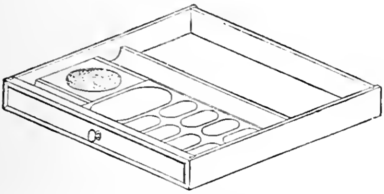
Work bench for crown and bridge and metal work in general.

FIG. 2

Work bench, closed.

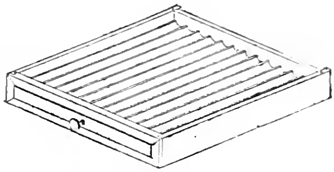
in place, the treadle only of which projects in front of the bench. The bellows is connected with a metal pipe in the rear right-hand corner of the bench, and this pipe extends upward behind the drawers and through

Fig. 3



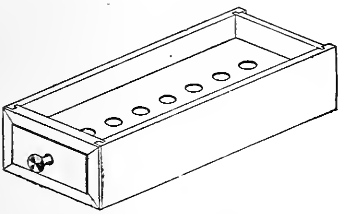
Drawer for gold, solder, plate, and wire, with borax block, etc.

Fig. 4



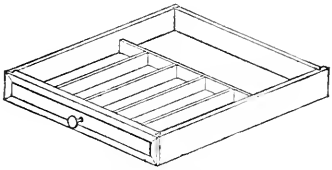
Drawer for files and scrapers.

Fig. 5



Drawer for mounted grinding wheels.

Fig. 6



Drawer for pliers, cutters, benders, etc.

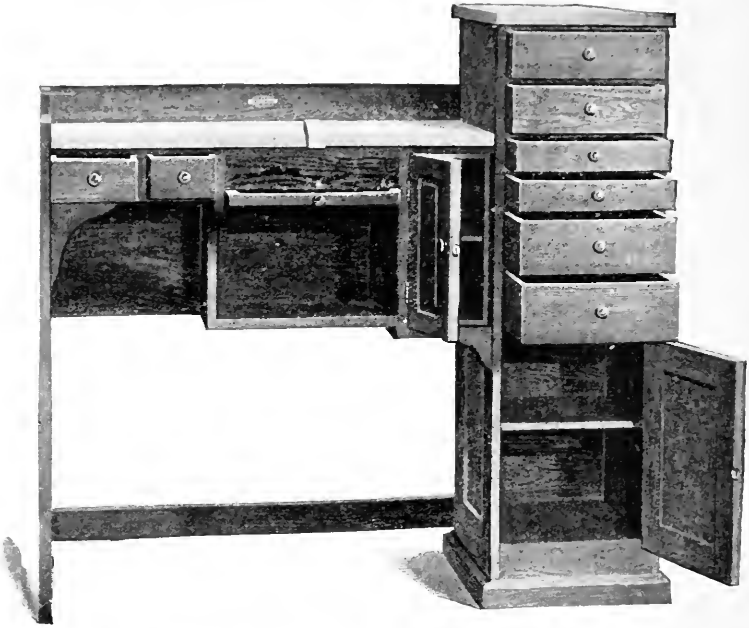
the marble slab, and is surmounted by a neat polished brass casting with a horizontal nozzle to which the blowpipe tubing may be attached. This arrangement of the bellows overcomes the disadvantages of having the bellows continually under foot, and the tubing lying across the bench and hanging down in front. The bellows is made specially for this bench and is shipped connected and ready for use, but the ordinary bellows can be adapted to the compartment and easily connected to the metal pipe.

If the compressed air tank be used instead of the bellows, the lower compartment may be utilized as a drawer by withdrawing and reversing it, the other end of the drawer being finished and furnished with a drawer pull. The front end then becomes the rear end and the opening is closed by a slide furnished with all benches.

Under a filing block, which is furnished with the bench, near the left-hand end of the bench, is a drawer arranged with concaved blocks cut out of the solid wood. One of these concavities is elliptical in shape for gold plate, wire, etc., and five are circular in shape for different grades of gold solder or for other purposes. The drawer also contains a slightly concaved borax block or marble $\frac{7}{8}$ inch thick, and a grooved block from which brushes and small instruments may be readily taken. This drawer can only be opened by one who knows the location of a secret lock. Below the gold drawer is a slide of zinc in a wooden frame for catching gold filings. This slide gradually slopes downward to a central recess, which has a screw cap removable from below.

The top of the bench represented by Fig. 9 is a marble slab $19\frac{1}{2} \times 24$

FIG. 7



Work bench for vulcanite work.

FIG. 8

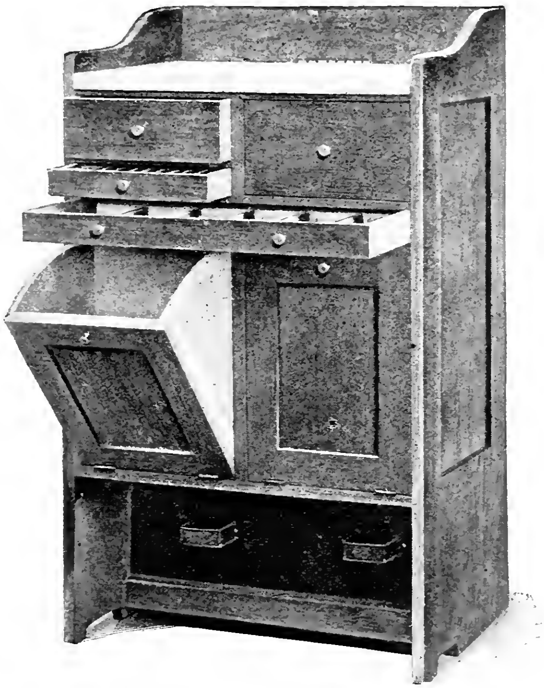
Work bench for gold work.

inches, and overhangs the front, so that the dentist may stand close without touching the lower part. Around the sides and back is a rail, and at the back of the marble slab is an opening $1\frac{3}{4} \times 6$ inches, which

enters a metal chute for carrying away waste plaster, etc., through the bench, back of the drawers, to a galvanized iron receptacle beneath. This receptacle rests upon a shelf, and can be drawn forward by its two handles and removed when its contents are to be disposed of. The left upper drawer is for rubber bowls and articulators.

Beneath the upper drawer is a shallower one arranged with compartments, concave in shape, for spatulas, plaster knives, etc., the arrangement of the compartments being such that the various tools remain where placed. At the right of the two drawers already mentioned is a tight drawer lined with zinc, for sand, molding rings, ladles, and all appliances used in casting. The long drawer above the two lower

Fig. 9



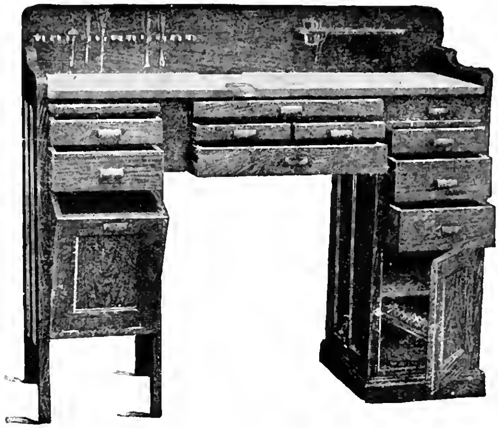
Work-bench for plaster and sand work.

compartments contains divisions for eighteen impression trays. The two lower compartments are V shaped and hinged at the lower point. One is for impression plaster and the other for cast plaster. The centre of gravity of these drawers is such that they remain in either an open or closed position as placed. These benches have not been improved upon for convenience. In laboratories, where space must be economized, one of the combination benches designed for the several classes of work may be desirable. Figs. 10, 11, and 12 show two recent approved patterns.

Accessories of the Work-bench.—A good vise is an important adjunct to the work-bench, and is indispensable when the draw-plate is used for reducing the size of gold, platinum, or silver wire.

Rubber slabs $\frac{1}{2}$ inch in thickness by 6 inches square afford excellent rests, not only for the protection of the top of the bench from injury by contact with dies and counter-dies in the preliminary stage of plate-making, but also as pliant and elastic rests for the metallic or rubber denture during filing and finishing.

Fig. 10



Combination bench for general laboratory work.

Molding Bench.—This article of laboratory furniture, shown by Fig. 13, demands special attention in its construction, otherwise it will prove a constant annoyance, as no ordinary wooden box will remain tight enough

Fig. 11

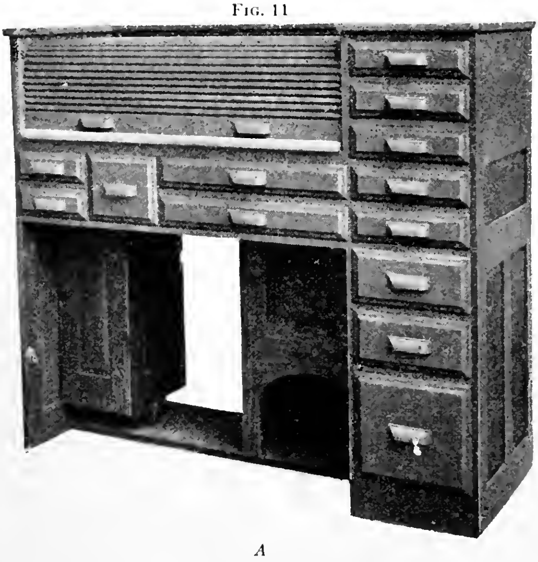
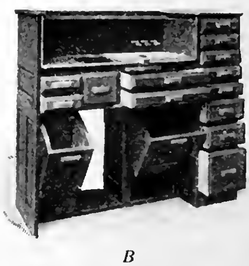


Fig. 12



A *B*

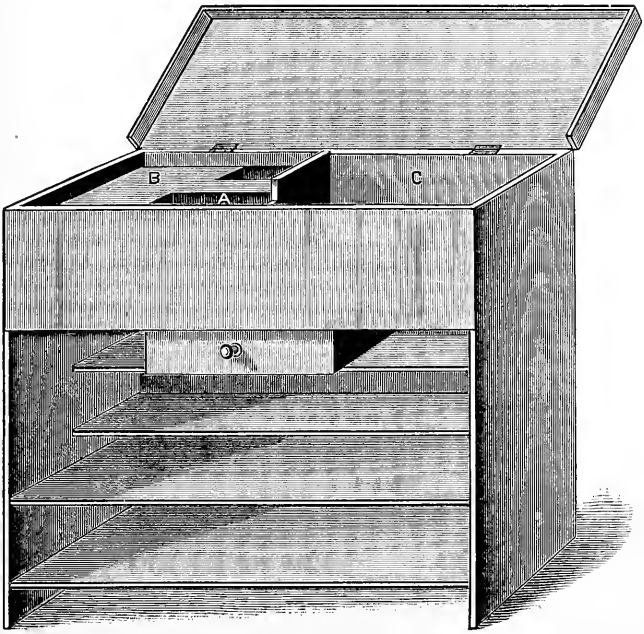
Combination bench for general laboratory work: *A*, Closed; *B*, open.

to prevent the molding material from falling through its seams upon the floor. The diagram shows the general design of one which has been found practical and convenient.

"The box is divided into two compartments and is lined with sheet

copper. The compartment on the right hand (C) is for the damp molding sand ready for use. The left-hand compartment contains a fixed block (A) placed in the front right-hand corner: the face of this block is about 6 inches square and about 1 inch below the edge of the box. On this the molding is done. The remaining portion of this compartment is covered with a movable cast-iron tray (B) on which molds are set when ready to pour. After the sand has been used, it is passed to the box beneath through a square hole at the right-hand corner of the tray. By this arrangement the wet and dry sand are kept separate, and the tray is not encumbered with the sand that has been used. Underneath the box is a drawer in which

FIG. 13



Molding bench: A, Molding block; B, iron tray; C, compartment for molding material ready for use. (Trueman.)

the tools used in molding are kept, and underneath this, forming a stand for the box, are four strong shelves covered with sheet zinc to prevent wear, on which the flasks, new and old dies, zinc and lead, etc., are kept."

When, for any reason, the laboratory is not to contain a molding bench, a very satisfactory substitute maybe found in a tray, 18×24 inches, with a 2-inch ledge around one long and the two short sides, covered with sheet copper or zinc. This may be placed upon the work-bench when needed and the molding operations performed on it, and, as it takes up little room, may be conveniently stored when not in use. In conjunction with this must be provided an earthen crock to store the sand in, or a tin container, such as is sold with the preparations of marble dust used for molding. The "molding blocks" presently to be described will be found useful adjuncts.

Accessories of the Molding Box.—Accessories of the molding box consist of the various sizes of the Bailey molding flask, which, with the method of using them, will be described under the head of Dies and Counter-dies; one Hawes flask (see Chapter IX.).

It is essential that all molding operations should be performed upon perfectly level surfaces, and for this purpose two or three "molding blocks" of seasoned pine, 8 inches square by 2 inches thick, will be found convenient aids. In order to avoid lumpiness and to secure uniformity of condition in the sand when moistening it preparatory to molding, a sieve of not less than 12 inches in diameter, with meshes of a minimum size of $\frac{1}{16}$ inch, will be found of value. The sieve should be formed of brass or copper wire, as an ordinary iron-wire sieve will soon become useless from oxidation, which is greatly assisted by contact with the wet molding sand. A painter's brush, $1\frac{1}{2}$ inches in diameter by 2 inches in length, will be found useful and convenient for the purpose of removing adherent particles of molding sand from the surface and interstices of the plaster model each time it is drawn from the sand

Fig. 14

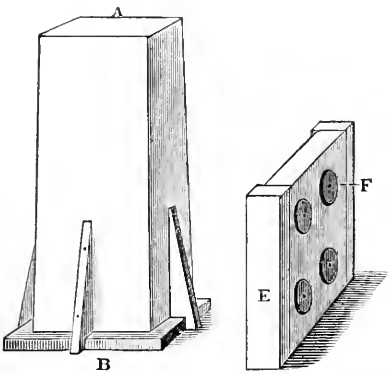
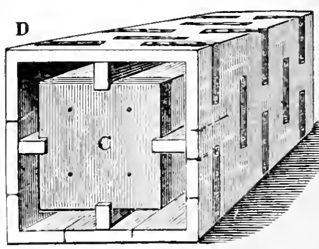


Fig. 15



Swaging block.

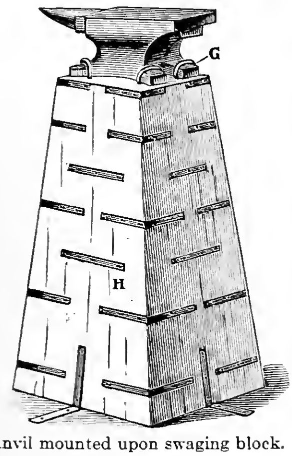
matrix: also, a small molding trowel for use in manipulating the sand, and a glass tube to blow out sand which has accidentally fallen into a finished mold.

Anvil and Swaging Block.—As the laboratory is often situated on an upper floor, the use of the hammer in swaging plates may be the cause of much annoyance from noise and vibration. This, however, can be entirely avoided by interposing rubber between the block and the floor upon which it rests. Fig. 14, *A*, shows the block of pine or poplar wood, $7\frac{1}{2}$ inches square by $23\frac{1}{2}$ inches high. *B* and *C* represent a sheet of rubber $8\frac{1}{2}$ inches square by $1\frac{1}{2}$ inches thick, securely fastened to the lower end of the block by screws. This block fits into a box made of $1\frac{1}{2}$-inch pine boards, broader below than above (Fig. 15, *D*), furnished with a loose bottom, made of 2-inch seasoned oak or ash, and provided with four pieces of solid rubber cylinder (Fig. 14, *E*) $1\frac{1}{2}$ inches in diameter by 2 inches long, let into it by holes of the same dimensions bored to a depth of $1\frac{1}{2}$ inches. Two thicknesses of rubber are thus interposed between the block upon which the anvils rests and the floor of the labor-

atory, and so much of the sound due to the percussive force of the hammer is thereby deadened that scarcely any noise or vibration will be observed by persons in other parts of the house.

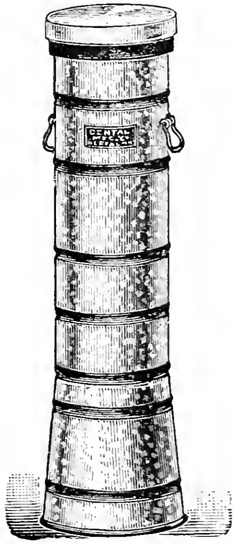
The anvil (Fig. 16), which should weigh not less than 40 pounds, may be securely fastened to the block upon which it rests by strong iron staples (*G*), and the box or outside covering of the block reinforced by iron bands, as shown at *H*. A swaging block so constructed may be looked upon as a permanent piece of laboratory furniture, and one that will not be likely to get out of order. An anvil resting upon a bed of sand contained in its base of sheet galvanized iron sold in the supply stores has proved very satisfactory in laboratories where space is a consideration. The sand takes up a great deal of the vibration imparted to the anvil in swaging. Fig. 17 shows the anvil and base. Two swaging hammers are required—one, weighing about 2 pounds, is of much use

FIG. 16



Anvil mounted upon swaging block.

FIG. 17



Swaging anvil.

in starting the plate. The heavier one, which should weigh 5½ or 6 pounds, is used with greater force after the plate has been made to partially conform to the zinc die when there is no longer danger of its pleating or folding.

Plaster Table and Sink.—The working of plaster, which forms so important a part of the operations of the dental laboratory, is entitled to much more care and attention than it usually receives at the hands of the mechanical dentist. It may be employed with neatness and precision, when its results become truly artistic, or, as is too often the case, it may be handled in so slovenly and untidy a manner as to greatly lower the standard of results, and, unless kept carefully within the precincts assigned it, cause the laboratory to become a most unattractive place. It is of importance, therefore, that a suitable table be provided upon which the casting and subsequent trimming of plaster casts and other parts of the laboratory

work depending upon the employment of plaster may be performed. The plaster table should also be supplied with a receptacle for the cuttings and refuse fragments. The table already described on page 22 has proved of very useful design.

The *accessories of the plaster table* consist, first, of two short, broad-necked bottles, for sandarac and shellac varnish, two or more flexible rubber plaster bowls, the same number of bone, ivory, or steel spatulas for mixing, one or more plaster knives, such as are sold at the dental depots for the purpose of reducing the size of plaster casts, for flasking in rubber or celluloid work, and a number of different sizes of camel's-hair brushes, which are indispensable in carrying the plaster into the deeper parts when running or casting impressions for partial dentures, and, indeed, all impressions having deep and more or less inaccessible points, which might not be perfectly reached by the gravitation of the plaster unassisted by some such means as is suggested by the use of the camel's-hair pencils or brushes.

Two kinds of varnish are usually employed in the preparation of the surfaces of impressions for running out the casts, so as to prevent too close adhesion of one to the other. One is transparent and dries upon the plaster without color. The other is of the color of burnt sienna, and imparts a dark-yellow stain to the plaster. The first is made by dissolving 5 ounces of gum sandarac in a quart of alcohol. The latter is formed of gum shellac and alcohol in the same proportions. Gum sandarac dissolves rather slowly, and requires a good quality of alcohol free from a very considerable percentage of water; otherwise it will have a milky appearance and will not afford a perfectly glazed surface when applied to the plaster impression. These two varnishes are employed for totally different purposes. In running out an impression the object should be to obtain a perfect surface to the cast, one that is free from air-bells or roughness of any kind, as such imperfections will be represented on rubber or celluloid dentures by multitudes of minute globules which are highly irritating to the mucous membrane of the mouth. The shellac varnish should be applied first, as it penetrates the plaster and discolors it sufficiently to serve as a guide in removing impressions from casts, and thus prevents the workman from injuring the teeth or prominent parts of the cast. After the shellac varnish has been allowed to dry, the sandarac should be applied with a camel's-hair brush until the surface is glazed. It should be laid on of a uniform thickness, but not in such quantity as to fill up deep places or to injure the correctness of the fac-simile of the mouth.

After the last coat of varnish has been allowed to dry, if the glazing of the surface is satisfactory, the plaster impression merely requires to be dipped in water to ensure saturation and to further harden the varnish, when it is ready for running the cast. Careful attention to these details will produce a cast possessing hardness of surface, and with the glazed appearance which is noticed when plaster is poured and allowed to set upon glass. This result, however, cannot be obtained when oil or solutions of soap have been used; such substances should never be applied to plaster impressions, as they do not afford surfaces sufficiently smooth or hard upon which to form rubber or celluloid dentures. To get the

best results in the handling of plaster, the latter in mixing should be slowly dropped into water until it becomes saturated and settles to the bottom of the bowl, so as to expel the air. The surplus of water is then poured off and the plaster well stirred, when it should be carried to the surface of the impression and into the deep parts with a camel's-hair brush, and the balance built up with the spatula.

Plaster of Paris is prepared from a native calcium sulphate known as gypsum ($CaSO_4+2H_2O$). There are other native sulphates of calcium: alabaster, which is a whitish translucent mineral; selenite, which is transparent; but gypsum, which occurs in opaque white masses, is the common source of plaster of Paris. The latter is obtained from gypsum by a partial dehydration, the process removing one of the molecules of the water of crystallization and leaving plaster of Paris ($CaSO_4+H_2O$), a substance which, when mixed with water, has the property of taking up the other molecule of water of crystallization and of crystallizing with the formation of the original hydrate ($CaSO_4+2H_2O$).

In making plaster of Paris, the gypsum is crushed into conveniently sized masses, is freed of its impurities, and roasted in an oven, a kettle, or a rotating cylinder at a temperature not exceeding 400° F. At 212° F. it begins to give off some of its combined water; at about 261° F. the best plaster of Paris is made, and if heated above 400° F. more than one molecule of water is driven off, and the property of the plaster to again take up this water is impaired or entirely destroyed. After calcining, the plaster is ground to various degrees of fineness, according to the use to which it is to be put.

When mixed with the correct proportion of water, plaster of Paris hardens by crystallization, and this hardening or setting is attended with a slight evolution of heat and a slight expansion, usually about $\frac{1}{500}$ of its volume. Various factors affect the amount of the expansion, which for obvious purposes of accuracy when used in the dental laboratory should be reduced to the minimum. The time occupied in setting varies with different plasters used in dental work, and various factors affect this time. The relationship of these various factors to both the degree of expansion and the time of setting will be discussed in Chapters VII. and VIII.

Two separate kinds of plaster are employed in the dental laboratory, one for taking impressions, and the other for dental casts.

Plaster when not being used should be kept covered to shield it from occasional dampness of the atmosphere and to protect it from water and foreign substances which might accidentally fall into it. The tin cans in which plaster is furnished by the dental depots are admirably suited to this purpose. The Ohmer dental bin is a more convenient receptacle. A closed tin container is provided at the bottom with a sieve actuated by a crank, by means of which the plaster may be slowly sifted into the mixing bowl, any large particles of extraneous matter being restrained by the sieve. The Ohmer bin is of good design, but should be of stronger construction. The author has recently obtained flour bins with a capacity of about 25 quarts which are of this same design, and, being admirably constructed, have been extremely satisfactory.

A sink with running water is practically a necessity for the work in plaster, and the plaster table should adjoin it. An ordinary iron sink,

such as is used in the kitchen or laundry will answer every purpose. Unless it is galvanized, it should be given a coat of pitch to prevent rust. Precaution must be taken to prevent clogging of the waste pipe with pieces of hardened plaster by providing guards and traps, and a slatted wooden false bottom which may be removed at will, may be fitted to the sink to both stop the larger pieces of plaster and offer a less hard and resistent surface to anything which might be broken by an accidental fall upon it.

Heat in the Laboratory. This agent is utilized in so many laboratory processes that it is deemed wise to discuss its sources and the principles underlying its production before taking up the methods which employ it. In the dental laboratory heat is obtained either from the combustion of fuel or from electric energy, the former being its commoner source. Solid fuel, as coal or coke, is no longer in use, having been succeeded almost entirely by either liquid or gaseous fuel. Alcohol, gasoline, and kerosene are the liquids used for this purpose; the gas is commonly either ordinary illuminating gas or natural gas in those regions in which it is available. These all owe their inflammability to the fact that they are hydrocarbons, combustion of which takes place when they are heated in air. One of the phenomena of combustion is the production of flame, which is simply burning gas.

The simplest flames[1] with which we are acquainted are those of hydrogen and carbon monoxide burning in air or oxygen. In such as these the burning gas undergoes no decomposition. The combustion consists of the simple union of an inflammable gas with oxygen:

$$H_2 + O = H_2O. \qquad\qquad 2CO + O_2 = 2CO_2.$$

The flame of either of these gases burning from the end of a tube appears as a burning cone, which upon investigation is found to be hollow, the combustion only taking place on the surface of the cone where the inflammable gas is mixed by diffusion with the air.

Substances which undergo decomposition and yield more than one product of combustion present a more complex flame structure. The flames of hydrocarbons commonly employed for illuminating purposes, such as the candle, illuminating gas, and oil, are practically identical in points of construction and a description of one will suffice for all.

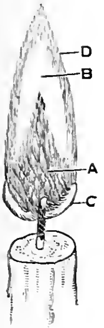
The Candle Flame.—On approaching the wick with the flame of a match, the wax (or other hydrocarbon of which the candle may be made) melts, is drawn up in the fibres of the wick by capillary attraction and there converted by the heat into gaseous hydrocarbons, which ignite, and in their chemical union with the oxygen of the air produce the flame. In such flames, as in the simpler ones already referred to, there is first, about the wick or burner, the dark cone, *A*, of heated unburned gases. Above and about the apex of this cone is a second cone, *B*, which in comparison with the rest of the flame, seems nearly opaque, and which emits a bright-yellow light. At the base of the flame there is a small calyx-like region, *C*, which appears bright blue in color and

[1] Manuscript on the flame furnished by J. D. Hodgen.

is non-luminous. Then enveloping the entire flame there is a faintly luminous, hardly perceptible, bluish-purple mantle, *D* (Fig. 18).

The dark cone, *A*, as has been explained, consists of unburned gases and in reality is not a part of the flame. However, chemical changes are taking place therein, owing to the heat from the sheath of combustion surrounding it.

Fig. 18



Candle flame

Cone B is ordinarily spoken of as the *luminous cone*. It has been concluded probable that the luminosity in flame is due to: (1) *the presence of solid matter*, (2) *the density of the flame gases*, and (3) *the temperature of the flame*.

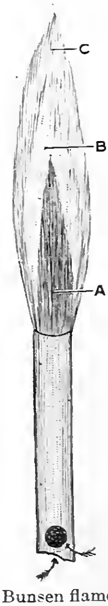
The blue region, *C*, may be regarded as being largely made up of the combustion of carbon monoxide.

The faintly luminous mantle, *D*, is probably a zone of complete combustion, in which those substances which have been incompletely oxidized in the other portions of the flame, chiefly hydrogen and carbon monoxide, are finally converted into water and carbon dioxide.

The Bunsen and Blowpipe Flame. When a certain amount of air is mixed with coal gas or any other hydrocarbon gas before combustion, the gas burns with a pale-blue, non-luminous, smokeless flame, which has a three-cone structure (Fig. 19).

Cone A contains the mixture of combustible gases and air (oxygen). In the Bunsen burner the air is drawn in through the openings near the base of the metal tube. The mouth blowpipe conveys a blast of air into the centre of the flame. In the compound blowpipe flame the blast of air (oxygen) is injected into the combustible gases from the lungs of the operator or by some mechanical means, such as a bellows, through a concentered tube, *D*, while the gas is conveyed by the outer and larger tube, *E* (Fig. 20).

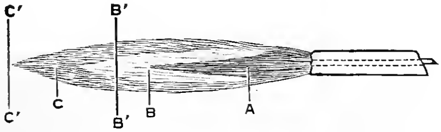
Fig. 19



Bunsen flame

The Reducing Flame.—The inner cone, *B*, presents the gas burning with a pale-blue flame, rendered so by the presence of oxygen in the gas. If an oxidized piece of copper be placed in a Bunsen or blowpipe flame in the position of

Fig. 20



Blowpipe flame.

the line marked *B′ B′*, it will be noticed that the metallic sheet brightens in the area covered by the flame. This is accounted for by the fact that this region of the flame contains highly heated but unburnt hydrogen or hydrocarbons, which have the power to abstract and then combine with the oxygen of the copper oxide, thus freeing or *reducing* the copper; hence, this region is known as the *deoxidizing or reducing flame*.

This is the flame used for soldering, as it reduces any oxides that may be on the solder, or parts to be soldered, and, also cutting off the oxygen of the air from contact with the heated metals, it prevents any reoxidation of them.

The Oxidizing Flame.—The outer cone, *C*, presents a pale-blue or purple color and is the zone of complete combustion. Gases which have escaped combustion in the inner cone are oxidized in the outer one by the ample supply of oxygen in the atmosphere surrounding it.

A bright piece of copper held in the position of the line *C′ C′* will be quickly darkened by the formation of copper oxide upon its surface. This is accounted for by the fact that the copper becomes heated, and, being unprotected, is unable to resist the affinity of the oxygen in the air surrounding it, and is therefore oxidized. Hence, the term *oxidizing flame.*

Any attempt at soldering with this flame results in oxidation of the base metals of the solder and parts to be soldered, so that additional fluxing will be necessary before the solder can flow. Continued misuse of the flame may so greatly raise the carat of the solder, by oxidizing out the base metals, as to make its fusing point dangerously high, or the presence of the oxides mixed with the solder may make its flowing impossible.

Because of the chemical nature of combustion, it is evident that the proportion between the air and the gas must be definite and fixed to obtain the highest heat, and this must be regulated when the blowpipe is in use. If too little air is supplied, imperfect combustion takes place and the full degree of heat is not developed. On the other hand, the luminosity of the flame is increased, the heat being inversely related to this. If too much air is forced in, the temperature of the flame must necessarily be reduced by the current of cool and uncombined air.

The various heat-producing appliances which burn gas operate under the principles above outlined. They will be described in the portions of this chapter which treat of their use. Gasoline and alcohol appliances will also be discussed later.

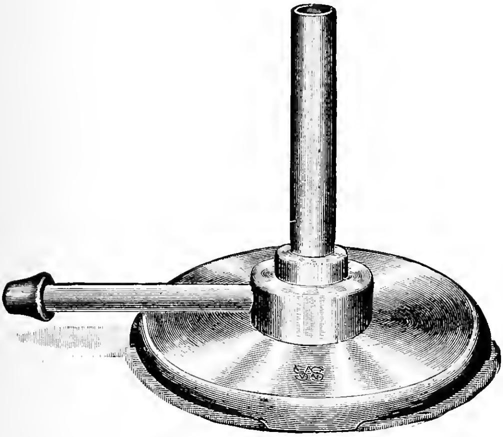
One of the commonest uses for heat in the laboratory is in the melting of metals.

Fig. 21 shows a form of Bunsen burner that has found favor for general laboratory uses. Greater heat may be obtained by using a larger burner. Recently an improvement on the Bunsen principle has been utilized by Dr. Méker of Paris in the construction of the Méker burner. In this the air and gas are more thoroughly mixed in the tube, the larger openings at the base admitting more air, and a wire gauze at the mouth of the tube prevents back firing. This burner, shown in Fig. 22, has greater heat-producing capacity than a Bunsen burner of equal size, and the flame is almost uniform in its heat.

Modes of Melting Metals.—The means employed for this purpose will depend upon the character of the metal or alloy to be fused. The fusing of such alloys as are used for dies and counter-dies in crown and bridge-work, which melt at temperatures ranging from 158° F. to 236° F.—and there are a large number of these alloys now in use—may be accomplished by simply placing a sample of any one of them in

a small iron ladle provided with a suitable handle, or in a copper ladle recently designed for the purpose (Fig. 23), and holding it over a Bunsen flame or the flame of an alcohol or oil lamp.

Fig. 21.



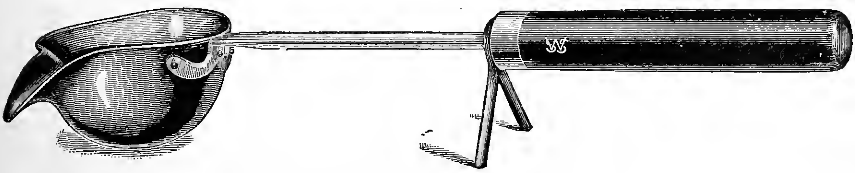
Bunsen burner for laboratory use.

Fig. 22

Méker burner.

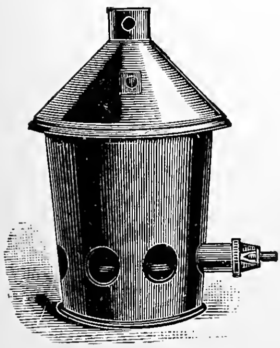
Metals and alloys used in the formation of dies and counter-dies melting in an iron ladle or at below red heat may be fused in an ordinary

Fig. 23



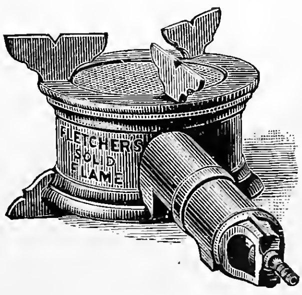
Ladle for fusible metal.

Fig. 24



Fletcher's furnace.

Fig. 25

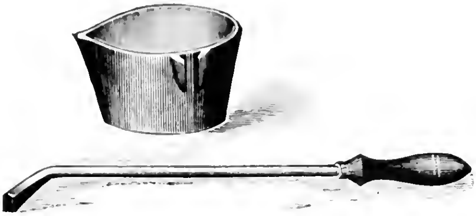


Burner for furnace.

stove or furnace, or, where gas is available, in one of the furnaces devised by Mr. Fletcher, of Warrington, England. Fig. 24 shows a furnace of

his design for melting zinc, lead, and other metals for dies and counter-dies, which, it is believed, is unexcelled by any other yet made.

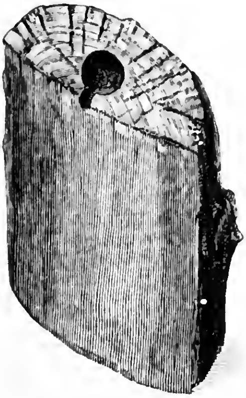
FIG. 26



Melting ladle and handle.

It works equally well with any gas supply available; the speed of working is, however, proportionate to the supply of gas. The burner can be removed from the casing and used for other purposes if desired. The cast-iron ladle and handle are shown in Fig. 26.

FIG. 27



A

FIG. 28

B

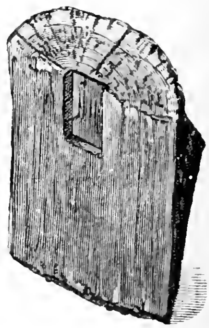
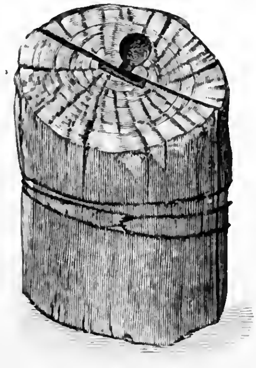


FIG. 29



Carbon support.

It should be remembered that zinc will, under favorable conditions, unite with iron, and it frequently attacks the cast-iron ladle in which it is melted, and may penetrate the side and escape into the fire. Accidents

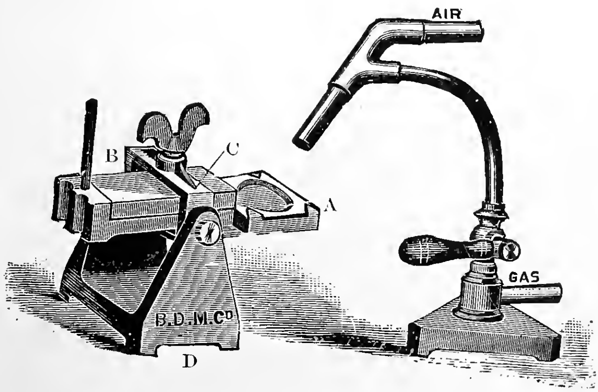
of this kind are more likely to occur when the ladle is new, and may be avoided by coating the inside with whiting previous to the first melting. This coating should be renewed until a protecting covering of oxide of iron has been formed after repeated use of the pot.

Small quantities of gold or silver may be melted by means of the ordinary blowpipe upon a support formed of charcoal. A good solid cylindrical piece of thoroughly charred pine coal should be selected, and divided into two equal halves by a vertical cut with a saw, as shown by Figs. 27, 28, 29. Upon the end of one half a depression should be cut for the reception of the metal to be melted (*A*). On the flat side of the other half, extending to the end, the ingot mold should be carved, of a size and shape governed by the requirements of the case (*B*). The two halves should then be brought together and secured by a piece of iron or copper wire, when they will be found to practically combine the requirements of a crucible and ingot mold.

The depression in which the metal is to be melted and the mold or receptacle should be connected by means of a gutter or groove. The flame of the blowpipe is directed upon the metal, and when thoroughly fluid the charcoal is tilted, so that the fused metal will run into the mold prepared for it in the opposite half of the charcoal. This is probably the simplest form of apparatus by which small quantities of metal can be melted, and is often employed in the dental laboratory and by jewellers.

Mr. Fletcher has devised an apparatus embodying the same general principles as the one just described for quickly obtaining ingots of gold and silver without the use of a furnace (Fig. 30): *A* representing a crucible of molded carbon, supported in position by an iron side-plate; *B*, the ingot mold; *C*, clamp holding ingot mold and crucible in position;

FIG. 30



Ingot mold and blowpipe.

D, cast-iron stand upon which the latter swivels. The metal to be melted is placed in the crucible (*A*), and the flame of the blowpipe is directed upon it until it is perfectly fused. The waste heat serves to make the ingot mold hot. The whole is tilted over by means of the

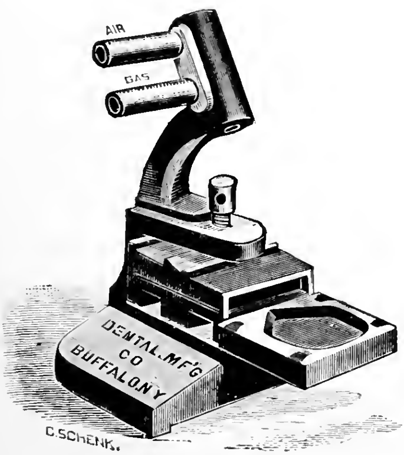
upright handle at the back of the mold. A sound ingot may be obtained by the use of this simple little apparatus in a few minutes.

Fig. 31 represents an improved form of the preceding melting arrangement. It differs in that the two parts of the ingot mold slide on each other to enable ingots of any width to be cast, and the blowpipe is part of the rocking stand. The bellows is connected to the upper tube and the gas to the lower by the usual means of india-rubber tubing.

Contrivances of this kind are, however, not applicable to melting operations involving quantities exceeding one ounce. In such cases it is better to employ a crucible and any stove or furnace in which the temperature can be raised sufficiently. This may be accomplished in an ordinary cooking stove, a blacksmith's forge, or a small fire-clay furnace by the use of anthracite coal, coke, or charcoal.

By far the most convenient, compact, and effective furnace for melting from one to ten ounces of gold which has ever been used is the crucible furnace (Fig. 32) invented by Mr. Fletcher, which can be obtained at the dental depots. It is perfectly adapted to the wants of the mechanical dentist. It is composed of a substance resembling fire-clay, but much lighter in weight, and said to possess only one-tenth its conducting power for heat. The furnace consists of a simple pot for holding the crucible, with a lid and a blowpipe, all mounted on a suitable cast-iron base. The casing holds the heat so perfectly that the most refractory substances can be fused with ease by the use of a common foot-blower. The power which can be obtained is far beyond what is required for most purposes, and is limited only by the fusibility of the crucible and casing. The graphite crucible made especially for the Fletcher furnace will hold about ten ounces of gold. An ordinary gas-supply pipe of $\frac{5}{16}$-inch or $\frac{3}{8}$-inch diameter will work it efficiently. The blast is obtained by means of a foot-blower connected with the blowpipe by a flexible rubber tube. It requires a much smaller supply of gas than any other furnace known: about ten cubic feet per hour is sufficient for most purposes. A gasoline generator has been devised by which these furnaces can be satisfactorily used when ordinary illuminating gas is not obtainable. Fig. 33 shows the generator attached to the furnace with foot-blower complete.

Fig. 31

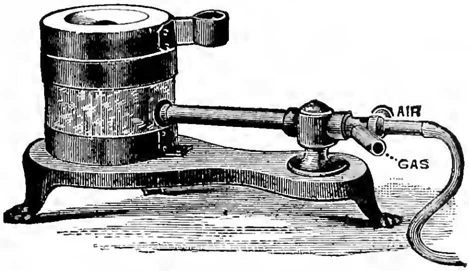


Fletcher's blowpipe and adjustable ingot mold.

In size the furnace is but 4 inches in diameter by 3 in height. From six to eight ounces of gold require from seven to twelve minutes for perfect fusion, the time depending on the gas supply and the pressure of air from the blower.

In melting any large amount of gold, particularly if the melting operation is performed in an ordinary coal stove, there is always danger

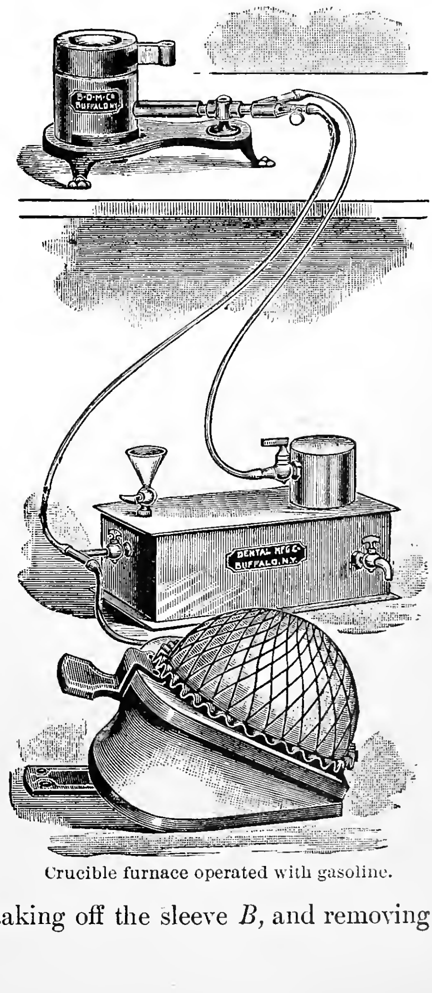
FIG. 32



Crucible furnace for melting silver and gold.

of loss by the escape of the precious metal through some defect in the bottom or sides of the crucible, when its recovery from among the fuel and ashes of the stove is almost impossible; but should such an accident occur when using the Fletcher furnace the complete recovery of the gold and silver would not be attended with the least difficulty.

FIG. 33



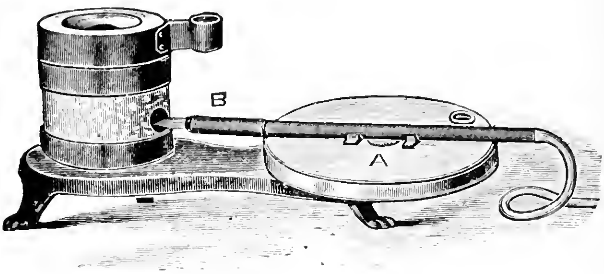
Crucible furnace operated with gasoline.

A modification of the apparatus has been made, adapting it to the use of refined petroleum instead of gas as a fuel (Fig. 34). Thus improved, it is said to be in no way inferior in efficiency to the gas furnace. The burner of this furnace is constructed upon the principle of an atomizer, which, of course, dispenses with a wick; it is furnished with a device for regulating the supply of oil, which is operated by the milled nut *A*, shown on the top of the reservoir in the cut, and for the supply of an annular jet of air, which is regulated by turning the sleeve (*B*). This burner is so arranged that in case any obstruction should occur it can be taken apart and cleaned by separating the burner from the reservoir, which is accomplished by loosening the small screws, drawing out the oil tube, taking off the sleeve *B*, and removing the inside tube.

These furnaces are so constructed that they may be used for either gas or petroleum, the lamp being fitted for adjustment in place of the gas burner, so that the same apparatus may be used for either. The blast is obtained by means of the foot-blower, which is connected with the furnace by the India-rubber tubing, as seen in the illustration (Fig. 34).

An injector gas furnace has also been perfected by Mr. Fletcher, which seems to be well adapted to the wants of the dentist or metal-

Fig. 34

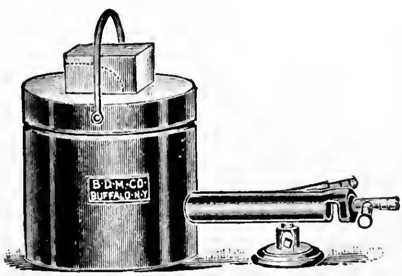


Crucible furnace using petroleum.

lurgist (Fig. 35), and it is claimed that its power and speed of working are practically without limit, depending only upon the gas and air supply.

With a $\frac{1}{2}$-inch gas pipe and the small foot-blower this furnace will melt a crucible full of cast-iron scraps in ten minutes. The supply of gas required is exceedingly small. Allowing five cubic feet of gas for heating up, it consumes about four feet of gas for every pound of metal melted. It is very simple in construction, and consists of two parts—an upper portion, which forms the cover, and a lower part, which holds the crucible while in operation.

Fig. 35



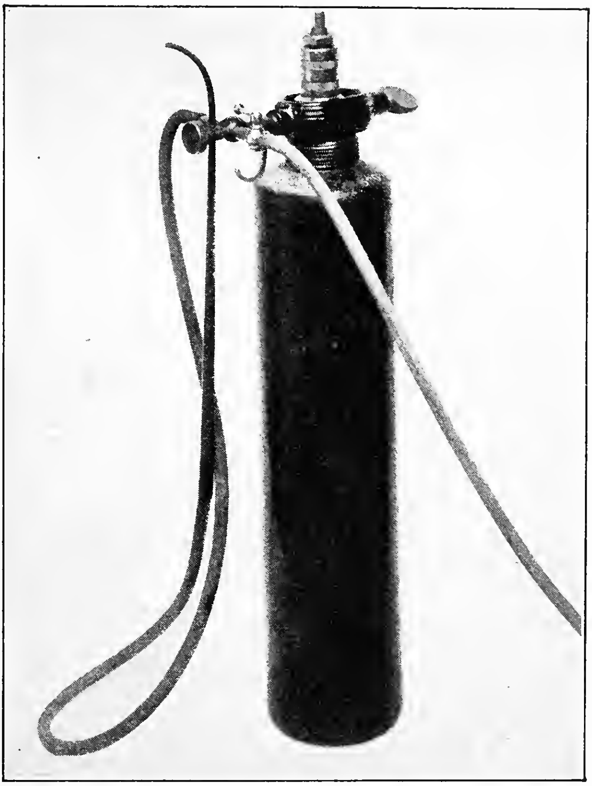
Injector furnace.

For melting platinum very high temperatures are required, and none of the appliances heretofore described produce sufficient heat for the purpose. In the soldering of continuous-gum dentures, in melting platinum scraps, and in some gold casting operations, greater heat is

necessary. Dr. J. Rollo Knapp made use of the principle of the oxy-hydrogen blowpipe in a nitrous oxide blowpipe of his design, in which the ordinary illuminating gas furnished the hydrogen element and a cylinder of nitrous oxide gas the oxygen element. The gases are mixed in a mixing chamber and issue from the blowpipe ready to combine, producing an intense heat when the proportions are properly regulated. LeCron's blowpipe, illustrated in Chapter XV., is built on this principle.

It has been found, however, that when a new cylinder is first connected with the apparatus the escape of the nitrous oxide under great pressure

Fig. 36



Lane-Seymour nitrous oxide blowpipe.

causes such a chilling of the yoke and mixing chamber, because of the absorption of heat by the nitrous oxide in passing from the liquid to the gaseous state, as to interfere with the working of the apparatus. Dr. W. H. Taggart has devised a means of preventing this by placing a very small burner, connected to the illuminating gas supply, beneath the nitrous oxide tube; the latter is kept warm, condensation is prevented, and the appliance works smoothly. After the pressure in the gas cylinder has

been considerably reduced in the natural course of using the gas, it is not necessary to keep the burner lighted, although better operation of the blowpipe is obtained by so doing. The blowpipe of Drs. Lane and Seymour, shown in Fig. 36, is constructed upon this plan.

Platinum scraps may be melted by a method devised by Dr. L. E. Custer, of Dayton, Ohio, which consists in the use of the intense heat of the electric arc. The 110-volt current is used. A large quantity of current is necessary, the fuse plugs being as large as No. 16 or 18 wire. A resistance coil of eight pounds of No. 18 copper wire should be in the circuit to prevent fusing the plug and to give a large arc. The platinum scraps should be placed upon a block of lime connected with one wire, and the other wire attached to a platinum-pointed piece of metal about $\frac{3}{4}$ inch in diameter. This platinum-tipped piece of metal is brought in contact with the scraps, and upon raising it a short distance an arc is formed directly upon the metal and it is melted. The arc can be carried about at will until the pieces are all brought into one mass.

Crucibles.—The term "crucible" was originally applied to a chemist's melting-pot, made of earthenware or other material, and so-called from the superstitious habit of the alchemists of marking such vessels with the sign of the cross. The term is now generally understood as designating vessels in which metals are melted at high temperatures.

A crucible should possess the power of resisting high temperatures without fusing or softening. It should also be capable of retaining sufficient strength when hot to prevent its crumbling or breaking when grasped with the tongs. Lastly, it should not crack either in heating or cooling.

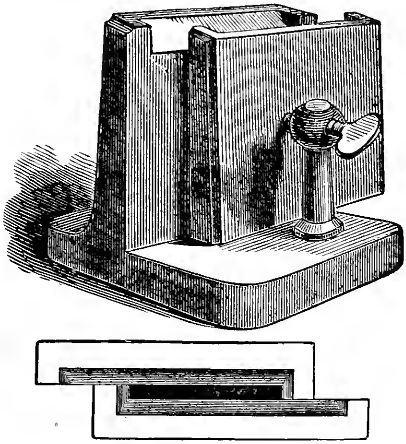
For the purpose of melting metals, crucibles are made of clay with admixture of silica, burnt clay, graphite, or other infusible material. For use in the dental laboratory, graphite crucibles, which can be obtained at the dental depots, will be found to answer every purpose; they are thoroughly reliable in strength and durability. They range in size fron 2 to 4 inches high, and are especially adapted for use in the Fletcher gas furnaces.

When the quantity of metal to be melted is very small—say, a half-ounce of gold—the smallest-sized Hessian crucible may be used in the small Fletcher apparatus.

Before melting any considerable quantity of gold the crucible should be tested, particularly if the melting operation is to be performed in an ordinary coal stove, where a defective crucible might be the means of a considerable loss. A small amount of borax should be placed in the vessel, which should then be exposed to a high temperature. Should it not be perfect, the borax glass will run through and glaze the surface on the outside. If the crucible is found to be impervious, it should be so inverted while yet hot that the borax glass may cover the surface of the lip or groove out of which the melted metal is to be poured. This facilitates the pouring and prevents any portion of the metal from adhering to the side of the crucible.

Ingot molds are constructed of various substances. For the reception of platinum melted by the oxyhydrogen blowpipe they are formed of lime or coke; for gold and silver they are commonly made of cast iron, about 2 inches square, and from $\frac{1}{8}$ to $\frac{3}{16}$ of an inch thick (Fig. 37), with slightly concave inner surfaces, as the shrinkage of the ingot is greatest in the centre. Ingot molds formed of soapstone are also employed, but they are not superior to those made of cast iron. Before pouring the ingot the mold should be heated, and when made to cast iron it should be held over a gas jet or oil flame until its inner surface is thoroughly coated with carbon: this at once prevents the possible contamination of the gold by contact with the iron, and

Fig. 37



Adjustable ingot mold.

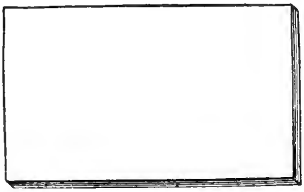
the carbon layer, being a good non-conductor, protects the melted metal at the moment of pouring from too rapid cooling, which otherwise might be the cause of a defective ingot.

The ingot of gold or silver should be as nearly rectangular as possible (Fig. 38), and the operation of pouring the melted metal from the crucible into the ingot mold cannot be considered as successful unless this result has been attained. The experienced workman holds the ingot mold, which should be provided with a suitable handle, with the left hand, while with the right he removes the crucible from the furnace and quickly carries it to the ingot mold, which he slightly tilts so that the melted metal may first strike the side of the mold; but he quickly brings the mold to a level before the last of the fused metal leaves the crucible, and thus avoids the danger of confining air at the deepest part of the ingot mold, which would cause the ingot to assume an irregular shape (Fig. 39).

The necessity of heating the ingot mold just before it is to receive the melted metal becomes apparent when we remember that gold fuses at 2012° F., while the iron ingot mold at the temperature of the atmos-

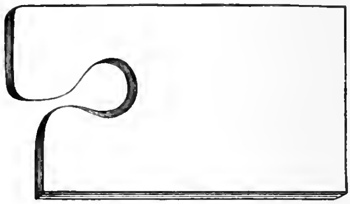
phere would be about 70° F., and when the amount of gold and silver to be melted is but two or three ounces, the ingot mold, weighing in the neighborhood of twelve ounces, would abstract so much heat from

Fig. 38



Correctly made ingot.

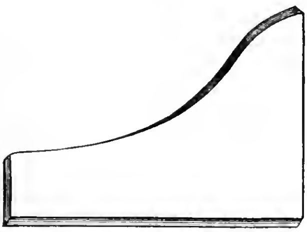
Fig. 39



Ingot incorrectly made; caused by confining air.

the metal as to cause it to become solid before it reaches the lower part of the mold, and the result would be an ingot triangular in shape (Fig. 40), which could only be at a disadvantage and loss.

Fig. 40

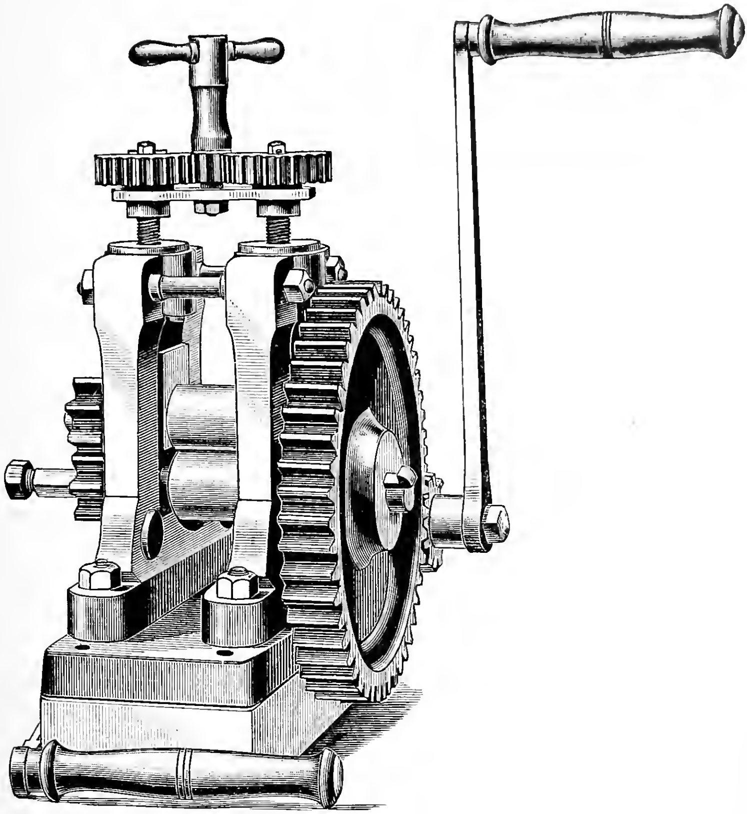


Ingot incorrectly made because of cold mold.

Rolling or laminating in the dental laboratory is accomplished by repeatedly passing the metallic ingot between cylindrical steel rollers from three to four inches in width. These are so arranged that by means of screws they are capable of being brought closer together every time the gold is passed through. (See Fig. 41.) The proper degree of attenuation is determined by the gauge plate (Fig. 42). After the ingot has been passed through the rolling mill a number of times it cannot be carried through in an opposite direction in order to increase its width without first carefully annealing it. This is done by laying the gold upon a large piece of charcoal and directing the flame of the blowpipe upon it until it becomes red hot. Failure to observe this precaution will invariably result in serious damage to the ingot by splitting.

Wire is made by means of the draw plate, which is formed of an oblong piece of hardened steel provided with a number of gradually diminishing holes enlarged on the side the metal enters (Fig. 43). The metal to be drawn through may be prepared in a cylindrical shape by melting and pouring into an ingot mold provided with a chamber for the purpose (some ingot molds are so constructed). The end of the rod should be filed so as to readily enter the draw plate, which must be firmly screwed in a vice. The metal is then, by means of strong pliers, drawn through the different holes of the draw plate consecutively until the desired size is reached. As the work progresses the wire will require frequent annealing, and to facilitate its passage through the draw plate it must be kept well oiled.

FIG. 41



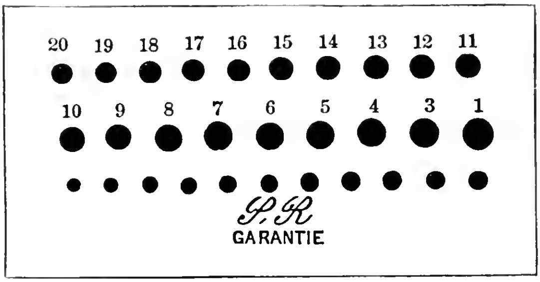
Geared rolling-mill.

FIG. 42

Standard wire gauge plate.

Half-round, square, and triangular wires are drawn in the same manner, except that the holes in the draw plate are made of these respective shapes, instead of being made round.

Fig. 43



Draw plate.

Soldering Apparatus and Accessories.—Soldering must also, to a certain extent, be regarded as coming under the general head of melting operations, since it refers to the union of two or more pieces of metal by means of a more fusible alloy. The conditions of successful soldering are—(1) contact of the two pieces to be united; (2) a clean metallic surface over which the solder is to flow; (3) a freely flowing solder; (4) proper amount and distribution of heat.

Contact of the pieces to be united is of the greatest importance. If, for example, the object to be soldered be an artificial denture, it is indispensable that the backings be quite or very nearly in contact with the plate, and if gum teeth be used that each backing touch its neighbor. This is not difficult to accomplish if the teeth have been carefully and accurately fitted to the plate and to each other. If, however, any defects of this character are found to exist after the teeth have been invested, they should be remedied by filling such spaces or crevices with small pieces of gold or silver, as the case may be, thus rendering the continuity of the parts complete. By the observance of this precaution much of the vexation in soldering experienced by beginners may be avoided, and when the other conditions named have been observed the operation becomes exceedingly simple.

Solder runs freely by the force of capillary attraction between two closely fitting surfaces, just as water will be drawn against gravity between two panes of glass in close contact. In soldering artificial dentures which have been carefully arranged with reference to contact of all the parts to be united, it is quite possible to complete the operation of soldering without using the blowpipe at all, by merely heating the whole case to the fusing point of the solder in a charcoal furnace with a good draft. The difficulties of soldering are mainly due to a violation of one or more of the rules herein given.

Cleanliness should always be strictly observed in soldering operations. The parts to be united should present bright and clean surfaces. Darkening or oxidation will always occur when gold or silver the purity of which has been reduced by alloying is heated to redness. A weak

solution of sulphuric acid and water, slightly heated, will quickly remove discoloration resulting from this cause, or the borax employed as a flux in soldering operations will effect the same result by dissolving the oxide which forms on the surface, while it also protects it from further oxidation by excluding the atmosphere.

Where broad surfaces are to be soldered together—as, for instance, in the construction of lower dentures, where, in order to get sufficient thickness, two thin plates are swaged separately and then united by soldering—it is even better, in addition to the pickling process, to thoroughly scrape the surfaces to be united, so as to ensure the flowing of the solder between the two plates. All surfaces to be soldered should receive a coating of borax before the heat is applied.

Borax, which is so indispensable, in soldering operations, has the chemical composition of $Na_2B_4O_7,10H_2O$; it is a pyroborate of sodium, and occurs in the waters of certain lakes in Thibet, Persia, and California. It crystallizes in six-sided prisms, which effloresce in dry air; it dissolves in 20 parts of cold and 6 of boiling water. On exposure to heat the 10 molecules of water of crystallization are expelled; at a higher temperature the salt fuses and becomes glass, in which state it has the power of dissolving metallic oxides; and it is this quality which makes it such an admirable flux in soldering and melting operations. It must, however, be kept scrupulously clean, and especially free from accidental admixture with plaster of Paris. Recently fluxes composed principally of borax, prepared and used in the form of dry powder, have been introduced, but they are in no respect superior to the old way of rubbing up the borax on a piece of ground glass with perfectly clean water until it assumes the consistence of cream, when it is applied to the surface to be soldered with a camel's-hair brush. A large crystal of borax should be selected for this purpose and given several coats of shellac varnish to prevent efflorescence. Powdered glass of borax is sometimes a useful and convenient adjunct when it is necessary to apply more borax to a hot surface, as in that form it may be dropped with the fingers upon any desired point of the heated denture without danger to the porcelain teeth.

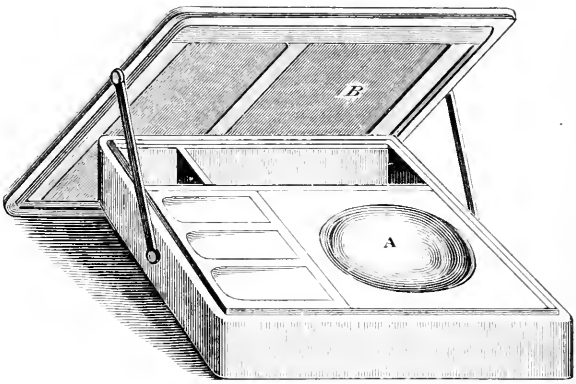
Fig. 44 shows a convenient and compact arrangement designed by Dr. H. H. Keith, of St. Louis, Missouri, in which may be kept the borax crystal, the different grades of solder, tweezers for handling small pieces of solder, and camel's-hair brushes. It is provided with a ground-glass plate, depressed in the centre (*A*), for rubbing the borax with water to the consistence suitable for application to the metallic surfaces to be soldered. When not in use it may be closed with the lid *B*, which protects the borax from contamination with plaster or other deleterious substances. This neat little accessory of the soldering table is made of walnut wood and is as ornamental as it is useful.

The soldering table is an indispensable piece of laboratory furniture, because it enables the operator to sit while soldering, thus affording a rest for the right arm while the hand guides the blowpipe, and it supplies a convenient place for charcoal "supports" and other soldering accessories. Its top must be of some incombustible material which will not crack under heat, such as boiler iron, which is to be preferred to slate

or cement for the reason named. A mechanical blower and blowpipe are necessary adjuncts, although where a supply of compressed air is available this may substitute the former, a pipe conveying it to the table being conveniently located near that supplying the gas.

The mouth blowpipe is an instrument which has long been used by workers in metals for the purpose of soldering together small pieces of metal and for melting and reducing purposes generally. The ordinary form (Fig. 45, *A*) consists of a conical brass tube, from 200 to 240 mm. long, curved at the narrower end to nearly a right angle, so that the flame may be conveniently directed upon the piece of metal to be soldered or melted, as the case may be, which is held upon some suitable support, such as a piece of charcoal, coke, or pumice-stone. When the blowpipe is used in its simplest form, by the mouth, the large end of the instrument is held between the lips and the small end toward the flame.

Fig 44



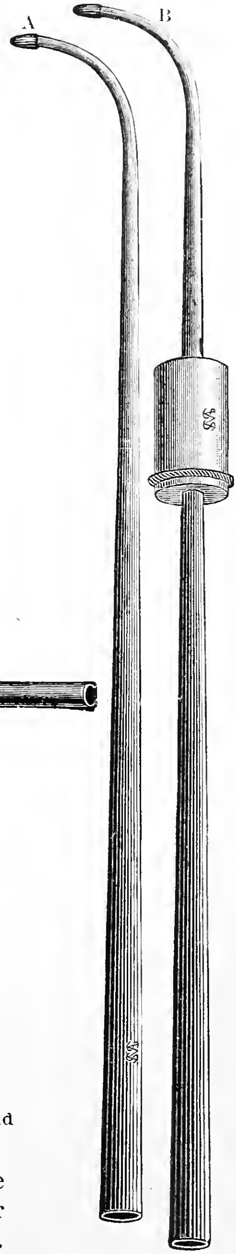
Box for borax and solder.

The blast should not be sustained by the respiratory organs, but, in order that an unbroken current may be kept up, the mouth should be filled with air, to be forced through the blowpipe by the muscles of the cheeks. While these are forcing the air through the blowpipe the connection between the chest and the cavity of the mouth should be closed by the palate, which thus performs the part of a valve. The beginner is liable to fall into the error of not closing the connection between the chest and the mouth at the proper instant, and of obtaining the force necessary to propel the air through the blowpipe from the lungs. That this manner of using the instrument may injure the organs of respiration cannot for a moment be doubted, and the operator should early acquire the proper method above described. To avoid tiring the muscles of the lips by long-continued blowing the trumpet mouth-piece has been recommended, and is shown in the annexed cut (Fig. 46). This is merely pressed against the open mouth, and an uninterrupted blast may be kept up for a long time without causing the least fatigue of the orbicularis oris, since, when the trumpet mouth-piece is used, that muscle takes but a passive part in the operation. This trumpet-piece, however, should

be so curved as to correspond with the shape of the mouth, otherwise it will require to be pressed very forcibly against the lips in order to prevent the escape of air.

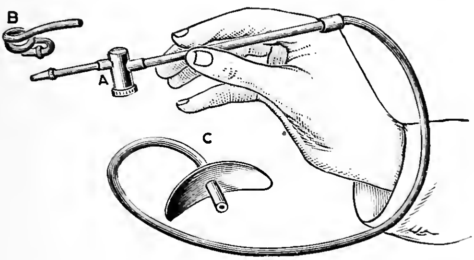
The blowpipe should be constructed of either brass or German silver, as these alloys are but poor conductors of heat. Silver is not well suited for

Fig. 45



Mouth blowpipes (brass).

Fig. 46

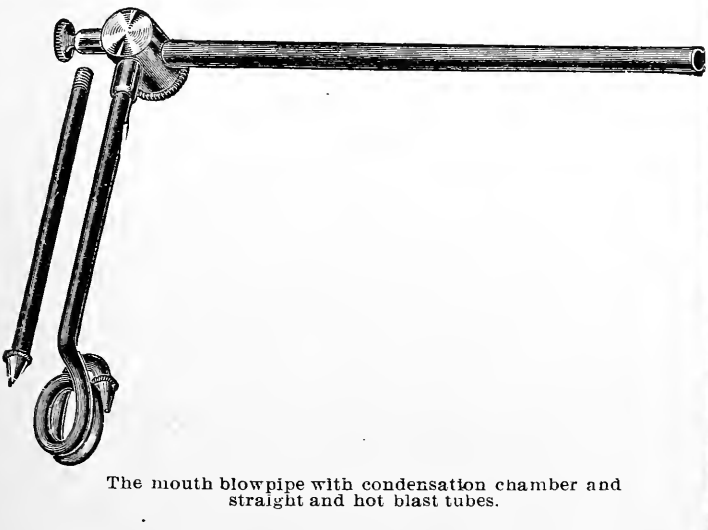


Mouth blowpipe with trumpet mouth-piece.

the purpose, because it transmits temperatures so readily that it soon becomes too hot for the fingers.

A long-continued and steady flame maintained by the mouth blowpipe is apt to cause disturbances in the flame from the collection of moisture

Fig. 47

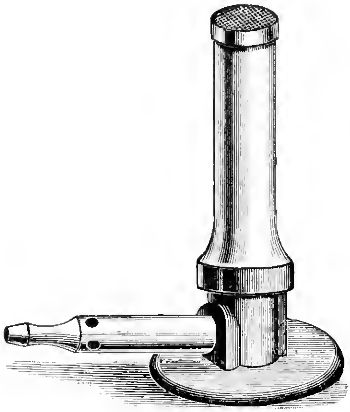


The mouth blowpipe with condensation chamber and straight and hot blast tubes.

in the tube, which is liable to be expelled by the pressure of the air. To avoid this a hollow chamber is constructed about midway in the instrument (Figs. 45, *B*, and 47). The length of the blowpipe should be adapted to the eye of the operator, so that the object upon which the flame is directed may be distinctly seen.

Wherever gas can be obtained, it furnishes at once the best and most economical, as well as safest, fuel for blowpipe work. Those who prefer the detached flame and simple form of blowpipe, which may be used either by the mouth or foot-blower, to the more recent compound apparatus of Mr. Fletcher, may readily construct a burner which will be found to answer every requirement of the laboratory by attaching to the base of an ordinary Bunsen burner, which may be obtained at the dental depots (see Fig. 48), a piece of brass tubing 6 inches in length by $1\frac{1}{4}$ inches in diameter. Over the top of this, in order to properly spread the flame, a piece of fine brass-wire gauze is fastened by means of a ring of sheet brass $\frac{1}{4}$ inch in width. Connection may be made with the gas bracket in almost any part of the room by means of flexible rubber tubing.

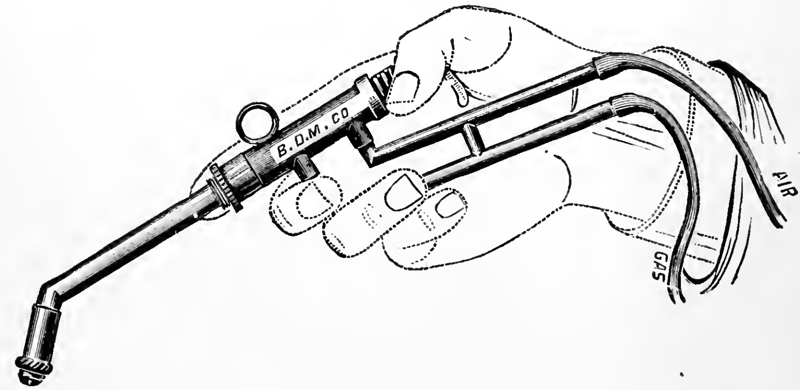
Fig. 48



Gas burner for use with mouth blowpipe.

The "automaton blowpipe," a somewhat recent improvement of Mr. Fletcher's, intended for general laboratory use and much employed by experts in crown and bridge-work where gas is available, is of the type of mechanical blowpipes which has quite superseded the mouth blowpipe in most soldering operations. The blast may be supplied by either the English, Burgess, or Fletcher foot-blower. The supply of gas and air is controlled by a longitudinal movement of the tube, worked by a spring under slight pressure of the hand when it is held as

Fig. 49

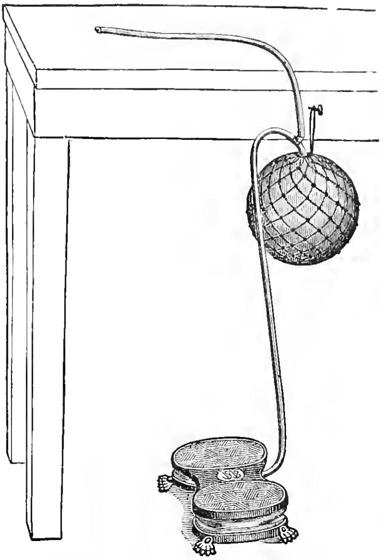


Automaton blowpipe.

shown in the illustration (Fig. 49). This is sufficient to give either a pointed jet or a full-sized flame at will. The gas passage does not close entirely, but allows of the escape of enough gas to prevent the flame from going out when the blowpipe is not in use, and it may be hung up by the ring which is attached to it when it is desirable to get it out of the hand.

Mr. Fletcher has devised a foot-blower, shown in Figs. 52 and 53, which may be used with any form of blowpipe. The reservoir of the upper portion (Fig. 52) which holds the air is, when the bellows is not in operation, merely a disk of thick coffer-dam rubber, which expands under the pressure of the air while the bellows is in motion, and thus affords a compact, powerful, and effective arrangement. The step for the foot is very low, and the blower may be used with ease whether the operator is standing or seated. The pressure is steady and equal, and if the rubber disk is distended until forced against the net, it can be increased to almost any extent desired, and will give, if required, a heavy and continuous blast through a pipe of $\frac{1}{4}$-inch clear bore.

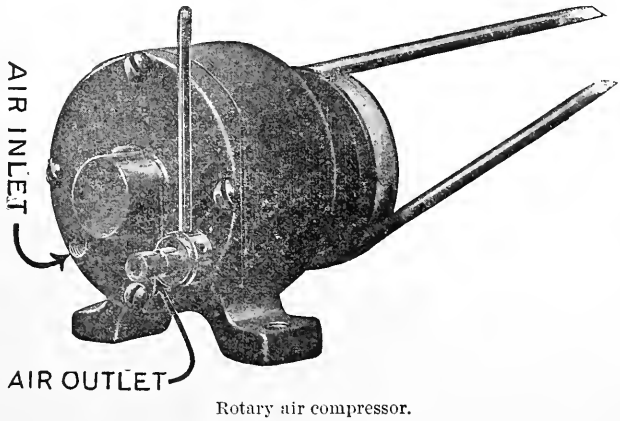
Fig. 50



English double-acting foot-bellows.

Recently, a small rotary compressor has been put on the market, which, when run by a motor, as the lathe motor, for example, supplies a very satisfactory current of air to operate a blowpipe. This is shown in Fig. 51. Many laboratories at the present time are supplied with compressed air, which, if obtainable in satisfactory amount, is the best source of air for extensive soldering operations. A pressure regulator should be connected at the outlet for the

Fig. 51



Rotary air compressor.

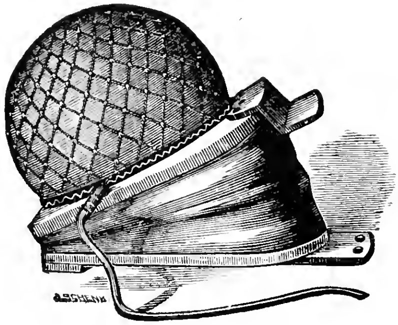
blowpipe supply, as no stop-cock can regulate the flow accurately. A pressure of from two to four pounds is correct for the ordinary blowpipe. In small operations, where great delicacy is required, the mouth

supply method insures greater satisfaction because it is always under perfect control.

Dr. George W. Melotte has devised a blowpipe especially for use in crown and bridge-work, which is in many respects similar to the preceding. The gas is supplied through a valved tube (Fig. 54) by connecting it with rubber tubing to a gas bracket. The spring valve which regulates the supply of gas may be set by means of a thumb-screw and jam-nut to a flame of any desired size. For delicate soldering it may be used with air current from the mouth by attaching a tube and mouth-piece to the longer pipe (Fig. 54). The method of using it as a hand blowpipe is illustrated in Fig. 55. It can also be used with the foot-bellows when a more powerful blast is required, or with nitrous oxide to procure an oxyhydrogen flame.

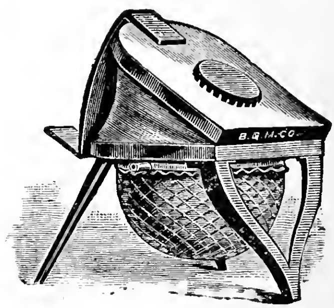
The blowpipe designed by Dr. F. H. Lee is shown in the illustration (Fig. 56). It is provided with a mouth-piece with rubber tubing, so that it can be operated by the mouth, or, by removing this

Fig. 52



Foot-bellows.

Fig. 53



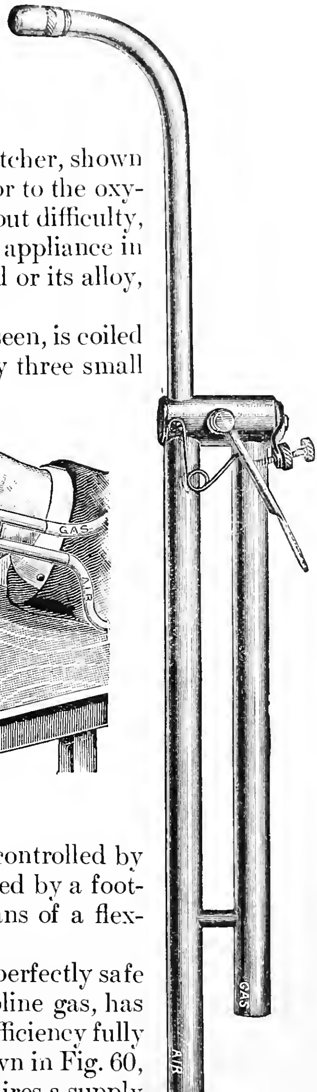
Foot-bellows.

attachment, with the foot-blower. The flame is controlled by the spring lever so accurately that a fine flame can be directed upon a particular spot. Releasing the lever shuts off the gas supply, allowing only enough to escape to keep the flame lighted for future use.

A most ingenious blowpipe for the soldering of regulating appliances and other small operations in which very delicate manipulation is required has been devised by Dr. J. G. Lane (Fig, 57). It is designed for use with air current supplied by the mouth, and may be fixed upon the table, leaving both hands free to handle the articles being soldered. The bell-shaped mouth reduces to the minimum the possibility of extinguishing the flame by too hard a blast. The tube which carries the air is carefully tapered to its outlet, where it corresponds in size to No. 25 standard wire gauge, the effect of which, when the air is forced through under high pressure, is to produce a very finely pointed flame, in which nearly perfect combustion takes place, and in consequence a high degree of heat is produced. This fine flame permits very accurate localizing of the heat. A great advantage in the soldering of small articles is found in the horizontal direction of the flame when the air is forced through

the blowpipe. As soon as the solder flows the operator ceases to blow, and the flame is immediately removed from the article soldered. If the blowpipe were directed vertically, stoppage of the air-current would not have this effect, and the article itself would have to be moved.

Fig. 54



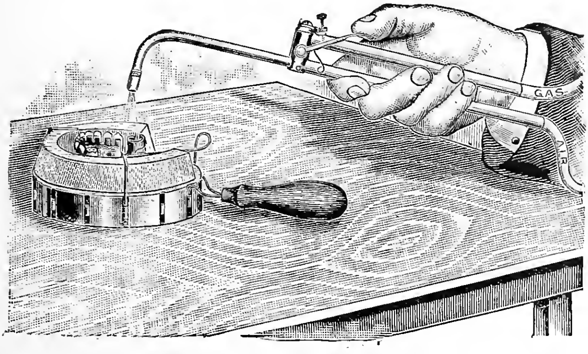
Melotte's blowpipe.

There are other forms of automatic blowpipes (Fig. 58), which are mounted on iron bases and provided with a ball joint, so as to be self-retentive and adjustable at the will of the operator

The hot-blast blowpipe devised by Mr. Fletcher, shown in Fig. 59, possesses a power but little inferior to the oxyhydrogen blowpipe. It fuses pure gold without difficulty, and is therefore of great value as a soldering appliance in continuous-gum work, where either pure gold or its alloy, with platinum, is used as the solder.

In this instrument the air pipe, as will be seen, is coiled around the gas pipe, and both are heated by three small

Fig. 55



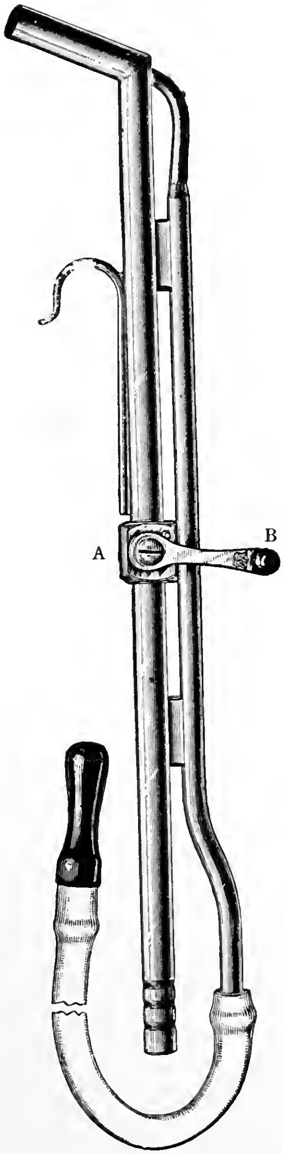
Method of using Melotte's blowpipe.

Bunsen burners, the gas supply to which is controlled by a separate stopcock. The air blast is obtained by a foot-blower connected with the blowpipe by means of a flexible rubber tube. (See Fig. 59.)

Where gas is not available, a simple and perfectly safe blowpipe, made expressly for use with gasoline gas, has been devised which possesses a power and efficiency fully equal to that obtained from coal-gas. As shown in Fig. 60, it is provided with a generator (*A*) which requires a supply of air under pressure, and is, therefore, operated in connection with a foot-bellows (*B*). To charge the generator, pour gasoline in the funnel which comes with the apparatus and which has been screwed down tight in the filler tube. When the gasoline rises in the funnel it is an indication that the requisite quantity has been poured in, the reservoir then

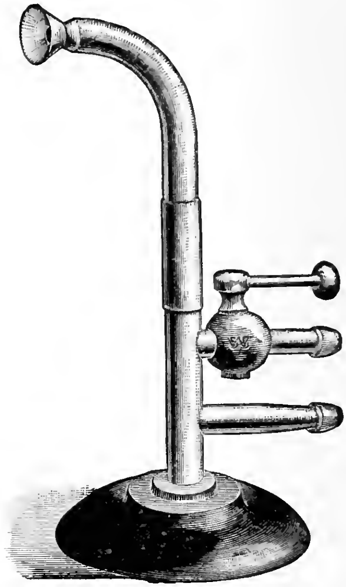
being about one-half full. The interior of the generator contains a large evaporating surface, and is provided with safety gauzes to prevent a

Fig. 56



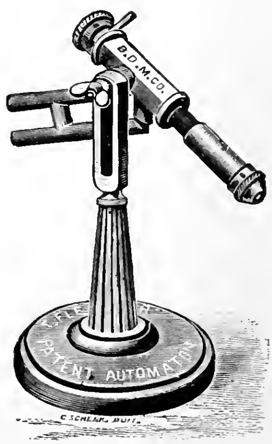
Lee's blowpipe.

Fig. 57



Lane's blowpipe for regulating appliances.

Fig. 58



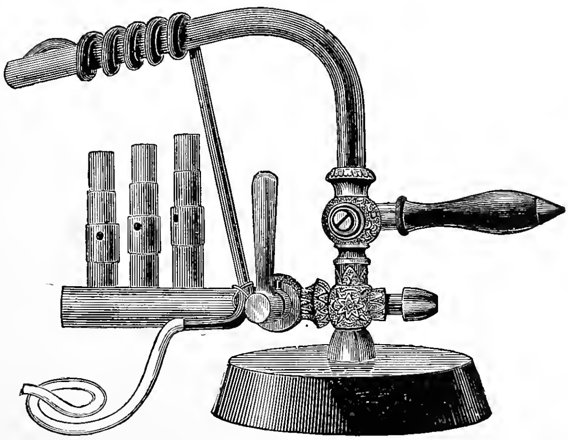
Blowpipe adjustable on movable stand.

flashing back of the flame. The turret top controls with a triple valve the various outlets and inlets, so that they may be all opened or closed with one motion. With the blowpipe and blower connected to the gen-

erator (as shown in the illustration), it is only necessary to operate the blower to obtain the gas ready for use. The air thus forced through the apparatus is highly charged with gasoline vapor, and the mixture burns with a considerable degree of heat. The turret should be turned to the left to open the valves. The size and character of the flame are controlled by the valve of the blowpipe shown in Fig. 61.

Different samples of gasoline will often be found to vary in quality. When a few drops of a good quality of this material are poured on a plate, it should evaporate quickly and completely, leaving no greasy residue: 74° to 76° gasoline, such as is commonly used in "vapor stoves" for culinary purposes, is suitable for use in the "gasoline generator and blowpipe." The heavier hydrocarbons or naphthas will not give as good results. It is important that all the tubing used in connection with this apparatus be kept in good order, otherwise its power may be greatly reduced. If the gasoline is of inferior quality and contains the heavier

Fig. 59



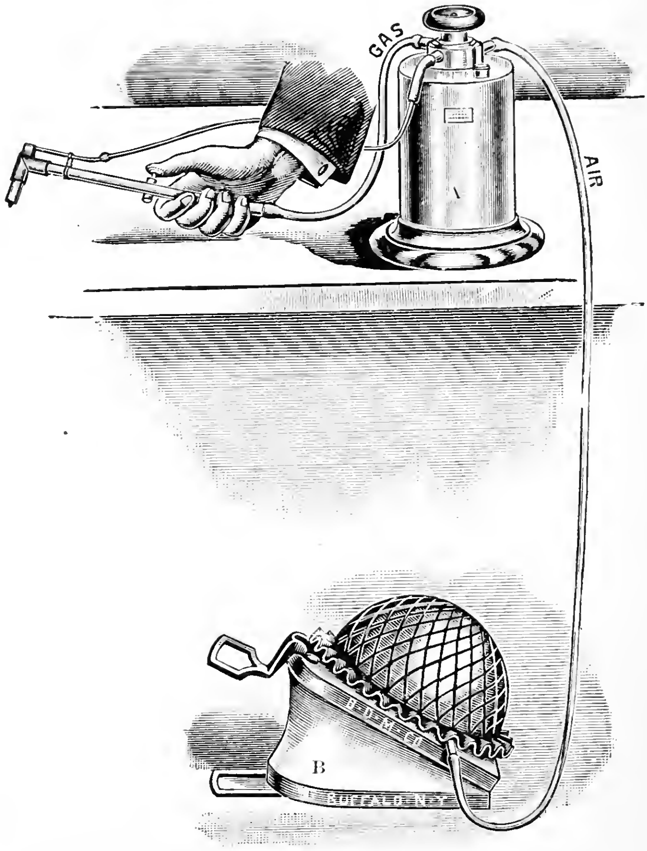
Hot-blast blowpipe.

oils, the generator will not work satisfactorily; it will then require emptying and refilling with a better quality of gasoline.

Heat-producing devices built upon a new principle and using gasoline as a fuel have recently been introduced into use. They are reliable, produce a high degree of heat, and in careful hands are perfectly safe. In localities where no gas supply exists, every laboratory need may be met by them. A blowpipe of this type which has great heat-producing capacity is illustrated in Fig. 62. It consists of a reservoir of brass, built strongly enough to stand considerable pressure. This is filled with gasoline to the point permitted by the funnel shown in the illustration, and the filler plug is screwed down tight. Then air is forced in by means of the pump in the handle of the apparatus, the gauge indicating the amount of pressure thus obtained, until about forty pounds to the square inch is registered, when the valve at the bottom of the pump should be closed to prevent the escape of the gas.

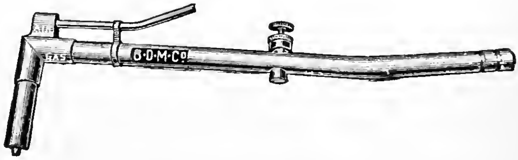
The burner (Fig. 63), to which the high heat efficiency of the appliance is due, consists of a combustion chamber (O) to which the gas is admitted in two jets (D and D), two needle valves controlling the jets, and a cup (G) underneath, which serves for the initial heating of the burner.

Fig. 60



Gasoline blowpipe apparatus. A. Generator. B. Foot-blower.

Fig. 61

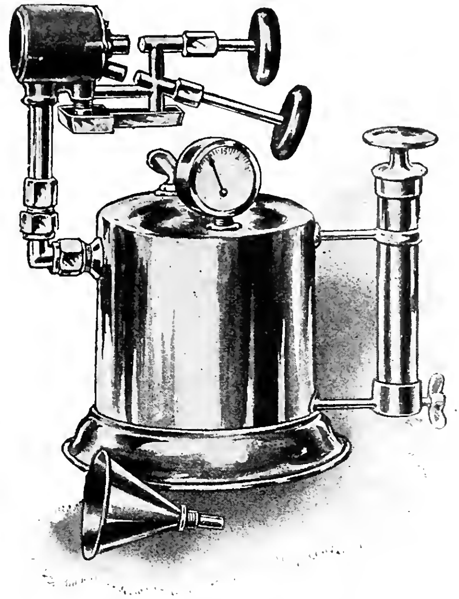


Gasoline blowpipe.

This cup is filled with gasoline which is lighted, and when nearly burned out the lower valve (E) is opened and the burner lighted. The upper valve (F) is then opened, which carries a mixture of air and gas through the centre of the chamber, blows the flame in the proper direction, and

also furnishes oxygen for the combustion of the gas obtained from the lower jet. The burner continues to heat the gasoline forced up by the

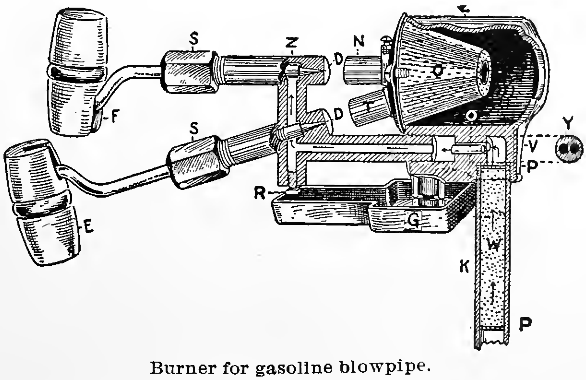
Fig. 62



Gasoline blow pipe and heater.

air pressure, and it is converted into gas by contact with the hot metal, so that its operation is continuous and limited only by the supply of fuel and by the air pressure which must be kept up. To secure the best results a correct adjustment of the two valves is necessary, and definite instructions for this accompany the apparatus. It is claimed that heat

Fig. 63

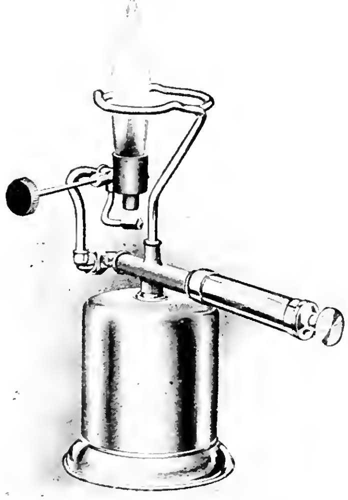


Burner for gasoline blowpipe.

of 3000° F. to 3500° F. may be obtained with the appliance. The swivels permit the burner to be turned in any direction. It may be used

as a blowpipe to flow 25 per cent. platinum solder, to heat the furnace in continuous-gum and porcelain crown work, or a furnace used in melting the more refractory metals. A heater constructed upon the principle of the Bunsen gas burner, which will be found most useful for the smaller heating operations is shown in Fig. 64. Recently a blowpipe burning wood alcohol made upon the same principle as the blowpipe described above has been introduced

Fig. 61



Gasoline Bunsen burner.

Supports. In melting small quantities of gold or silver or in soldering with the blowpipe flame it is necessary to perform these operations upon a support made of some suitable body, such as charcoal, coke, pumice-stone, or asbestos and plaster, charcoal and plaster, etc.

Well-burned charcoal is especially suited for both purposes, as it helps to increase the heat, and in the putting together of small quantities of gold or silver solders prevents oxidation of the base metals which are added to reduce the fusing point of the alloy and cause it to flow freely. Charcoal made from the light woods, such as pine, is best, because it is not so likely to throw sparks when the flame is directed upon it as are the harder coals, such as that made from oak; and, being softer, it is much better adapted to soldering operations in which it is necessary to hold the pieces to be united together by means of small nails or tacks thrust into the support; as, for instance, where a rim is to be soldered to a plate, the former must be brought in contact with the latter upon the charcoal, and so held during the preliminary soldering, which consists of uniting the rim to the plate with a small piece of solder at some one point, after which the accurate adjustment of the rim to the plate for final soldering is rendered much easier.

A good solid piece of charcoal, sufficiently large, should be selected, and bound with iron or copper wire to prevent its breaking into pieces. It should then receive a coating of plaster, from a quarter to a half inch in thickness, on all sides except the one upon which the object to be soldered is to rest. This adds to its strength and prevents soiling the fingers while it is being handled. Good charcoal, suitable for use in the dental laboratory, cannot, however, always be found when wanted, and it is therefore often necessary to use some other substance which may be more easily obtained. Thus those living in large cities may be compelled to employ pieces of coke as supports in soldering. Next to charcoal, coke is most suitable for this purpose. It is more durable than charcoal, and when such a support, composed of one large piece or even

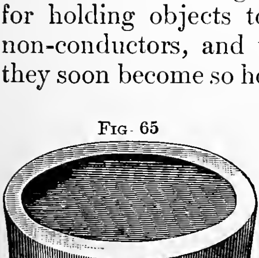
several smaller pieces, is bound together with wire and coated with plaster, it will last a long time. Large pieces of pumice-stone also answer well for the purpose of holding small objects while the flame of the blowpipe is directed upon them. Neither of these, however, is so well adapted as charcoal for holders, when small quantities of metals are to be melted, in consequence of their greater porosity and their hardness, which prevent the cutting of suitable pits for the reception of the metal to be fused.

A very good support for soldering purposes alone may be formed by filling a cup made of sheet iron or copper, 5 inches in diameter by 5 inches in depth, with a mixture of asbestos and plaster or plaster and finely broken charcoal. The vessel should be supplied with a wooden handle, fastened in the bottom, for convenience in handling.

Plattner's *Manual of Qualitative and Quantitative Analysis with the Blowpipe* gives a method of artificially preparing good solid supports of charcoal which might be found of value in the dental laboratory. It consists of mixing charcoal dust (which must not be too finely ground) with starch paste. The latter is prepared by combining 1 part of starch with 6 parts of boiling water. These are stirred in an earthen pot until all the meal is converted into paste. This paste is rubbed in a porcelain mortar with frequent additions of charcoal dust until the mass becomes too tough for further admixture, when enough of the coal-dust is kneaded in with the hands to render the whole mass stiff and plastic. From this the desired forms of supports can be made, allowed to dry gradually and thoroughly, and then heated to redness in a covered vessel, so as to char the starch paste. The charring may be regarded as complete when the evolution of gases from the mass ceases or when it has been heated to dull redness. Coals thus formed are of the proper firmness, and ring like ordinary good charcoal when thrown on the table.

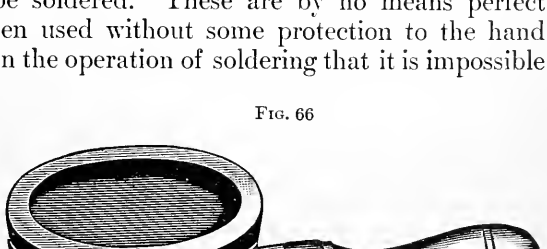
Blocks formed of graphite and fire-clay are now often used as supports for holding objects to be soldered. These are by no means perfect non-conductors, and when used without some protection to the hand they soon become so hot in the operation of soldering that it is impossible

Fig. 65



Soldering support.

Fig. 66



Soldering support and handle.

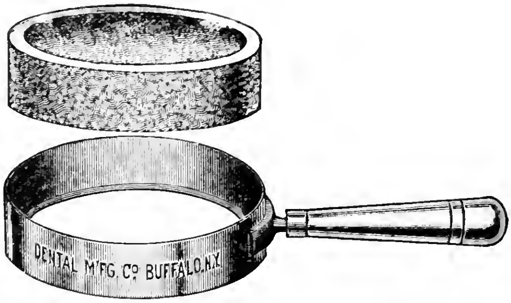
to hold them for any length of time. To overcome this difficulty, however, a very convenient device for holding the carbon, graphite, or other support has been introduced. (See Figs. 65 to 67.)

Soldering blocks have recently been formed of asbestos, and have found favor with many in preference to the "carbon block" for solder-

ing purposes. They are circular, depressed on each face, and 4 inches in diameter.

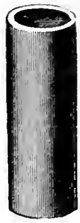
The carbon cylinder, made of the same composition as the carbon block, is a new form of support admirably adapted for soldering small

Fig. 67



Asbestos soldering support with handle detached.

Fig. 68

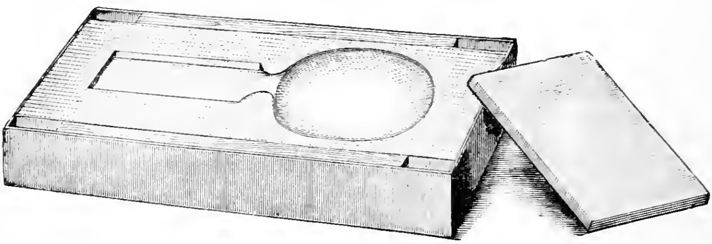


Soldering support for small articles.

articles, such as gold crowns, or for blowpipe assays. In size it is $1\frac{1}{8}$ inches in diameter by 3 inches in length (Fig. 68).

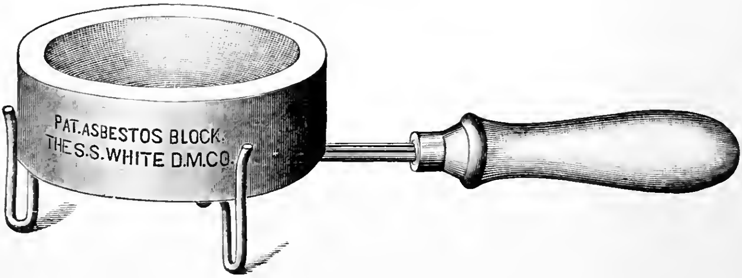
Among the more recently introduced forms of asbestos soldering and melting supports are those shown in the annexed illustrations. Fig. 69 represents a combined soldering, melting, and ingot block, 6

Fig. 69



Combined soldering, melting, and casting block.

Fig. 70

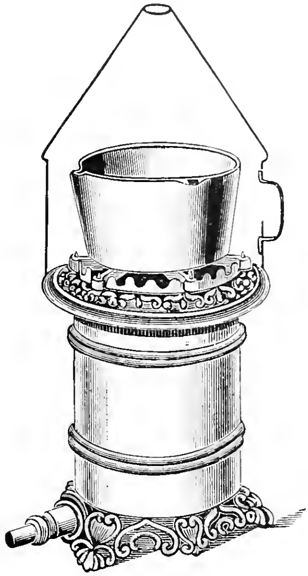


Soldering block.

inches long, $2\frac{1}{2}$ inches wide, by $\frac{1}{2}$ inch in thickness. Fig. 70 shows an asbestos support intended exclusively for soldering, $4\frac{1}{2}$ inches in diameter by $1\frac{3}{4}$ inches high, with concave top, and provided with a convenient holder, which also prevents the support from being laid flat upon the table while hot.

The best method of "heating up" a denture preparatory to soldering is to place it over a burner such as is employed in the dental laboratory for melting lead and zinc and for general heating purposes (Fig. 71). A ring of cast or sheet iron, 6 inches in diameter by 2 inches high, should then be placed around it for the purpose of holding the charcoal, which, in pieces the size of a hen's egg, should be built around the outside of the denture so that it may be uniformly heated.

Fig. 71

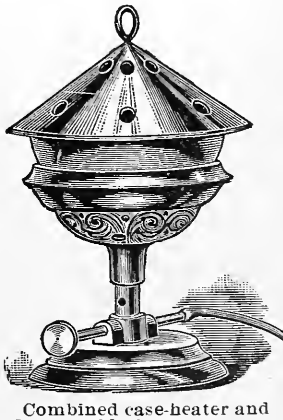


Laboratory burner.

A more recent device which has proved most satisfactory is a grill of heavy iron wire, which permits the heat to reach the invested piece and yet absorbs a lot of heat itself, and thus maintains the denture at a more constant temperature. This is especially true if charcoal or pieces of pumice stone are heaped about the invested article.

The cone or top of the apparatus just described may now be placed over it. The gas is then lighted, but the full head should not be turned on until the moisture of the investment has been driven off, when it may be gradually increased until the piece is heated to redness. About thirty minutes will be required for heating up, when the top may be removed and the piece raised to a red heat by means of the full flame of the blowpipe. The live coals used in heating up should also be placed around the outside of the investment to prevent the too rapid cooling of the piece should any delay in the soldering occur. When the latter operation has been satisfactorily completed, the top may be placed tightly on and all access of air prevented, in order that the piece may cool slowly and thus avoid the danger of cracking the teeth.

Fig. 72



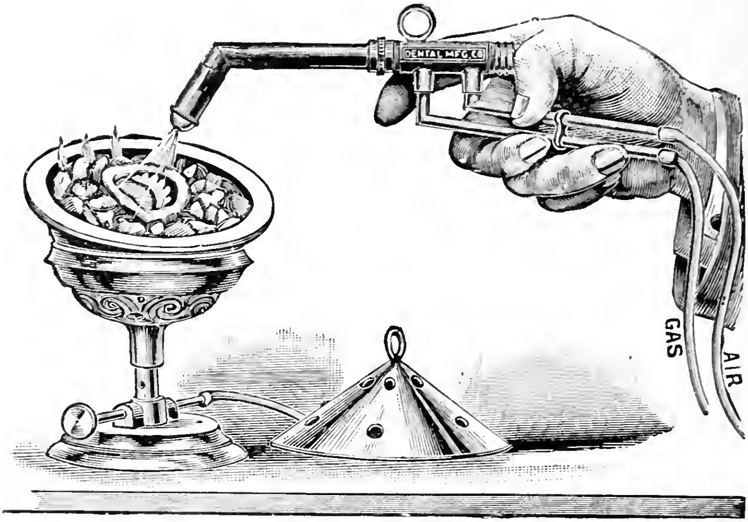
Combined case-heater and soldering cup.

The "Lewis" combined case heater and soldering cup (Fig. 72) is a recently improved device for drying out and soldering an invested piece of gold work without removing until completed. It consists of an iron cup or hemisphere, with suitable openings for the admission of heat from below, supported by another iron cup attached to an improved Bunsen burner and rotating on it. The upper hemisphere is capable of being swivelled or tilted in any position desired to facilitate the flowing of the solder and to bring all parts under the action of the blowpipe.

The cup is filled with pieces of broken pumice or coils of asbestos

rope, upon which the case rests. To dry out an invested denture it is arranged in the cup, the burner lighted, and the cover placed on to

Fig. 73



Case-heater and soldering cup in use.

retain the heat. After thoroughly drying, which should be preliminary to the final heating, the temperature should be raised by increasing the flow of gas until the whole piece has assumed a dull-red appearance, when the top cover may be removed, the cup tilted to a convenient

Fig. 74

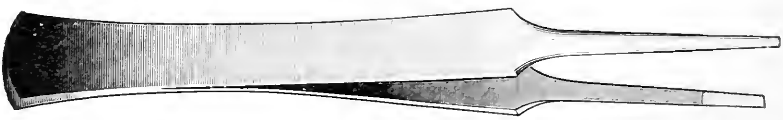


Fig. 75

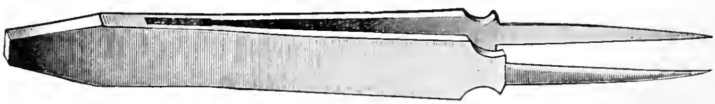
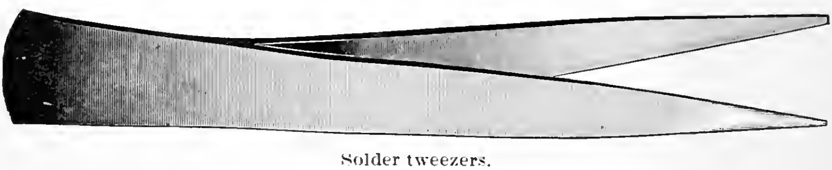


Fig. 76



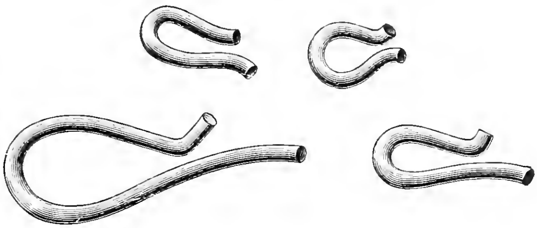
Solder tweezers.

position, the blowpipe brought into use, and the soldering finished. The burner underneath should remain lighted during the entire operation. The position or angle of the cup may be changed by a slight pressure with the blowpipe on its flanged edge.

Suitable solder tweezers, designed for placing pieces of solder upon parts to be united are important accessories of the soldering table. Figs. 74 to 76 show the ordinary forms of these, while Fig. 78 shows a pair with long reach, suitable for placing solder on a case while it is hot. The solder tongs, shown in Fig. 79, will be found most convenient in handling invested pieces during the soldering process, and as muffle tongs in baking porcelain crowns and bridges.

Wire clamps are indispensable in a certain class of soldering operations, and a small collection of different sizes of such forms as are

FIG. 77



Wire clamps.

shown in Fig. 77, made of No. 14 iron wire, should always be kept on hand ready for use. The smaller clamps shown in the illustration are especially useful in the construction of lower metallic plates. When two thin pieces have been swaged separately, with a view to uniting them by soldering, there is always danger of their being forced apart by the calcination of the borax which is present as a flux, and by expansion when the heat is applied; it is necessary, therefore, to hold them together temporarily until the preliminary or partial soldering is accomplished.

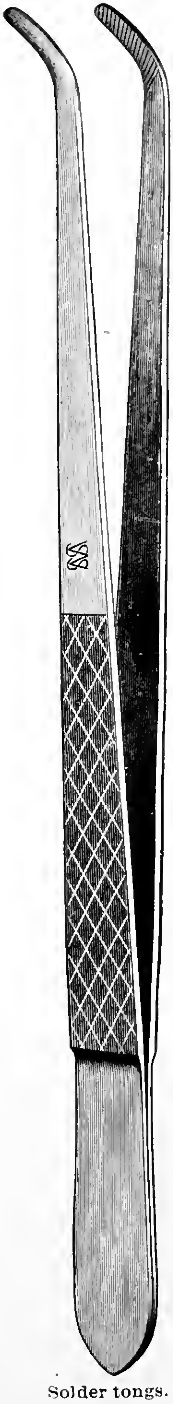
In soldering a chamber cap to an upper plate the cap is almost certain to change its relation to the plate during the soldering unless secured *in situ* by a stout wire clamp. For this purpose it is well to have on hand a few different sizes of the larger clamp shown in Fig. 77.

Pickling Solutions.—After removing the investing materials from around the soldered dentures—which, however, should never be done if porcelain teeth are present until the case has been allowed to cool slowly and perfectly—it may be placed in a pickling solution composed of sulphuric acid 1 part, water 4 parts, for the purpose of dissolving the fused borax and the oxide of copper which darkens the surface of gold or silver into which it usually enters as an alloy. Dilute sulphuric acid will dissolve both at ordinary temperatures, but its action may be greatly hastened by heating it to 212° F. The oxide is converted into a soluble sulphate which is dissolved by the water present in a dilute solution, the undiluted acid being less efficient as a pickle. This may be done in a copper pickling pan, such as is sold for the purpose at the dental depots, (see Fig. 80), or in a Wedgwood evaporating dish, similar to those used by chemists. A porcelain casserole (Fig. 81) is a very useful container for the pickle. It should be mounted on a chemist's tripod. Sulphuric acid is corrosive and destructive to the clothing; hence, ordinary glass vessels are not safe in which to heat the solution on account of their

Fig. 78

Long solder tweezers.

Fig. 79

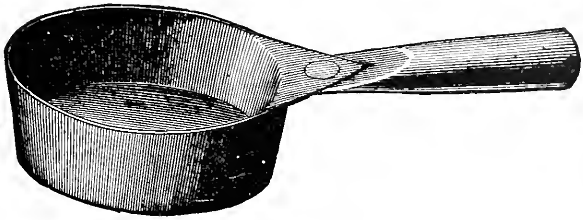


Solder tongs.

liability to fracture, and porcelain ware of the quality usually made for domestic use will not retain the acid, which soon dissolves the glazing from the surface, after which it is liable to escape through the bottom of the vessel.

A strong solution of common alum may be used instead of the acid, but it must be heated to the boiling point to develop its solvent properties.

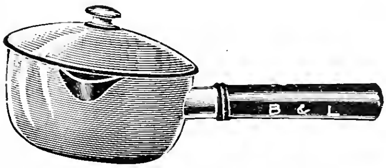
FIG. 80



Pickling pan.

When the same pickling solution has been used a number of times it becomes quite green in color, and crystals of sulphate of copper ($CuSO_4$) form around the edge of the pan. These are the result of the action of the acid upon the oxide, and they redissolve when the solution is again

FIG. 81



Porcelain casserole for use in pickling.

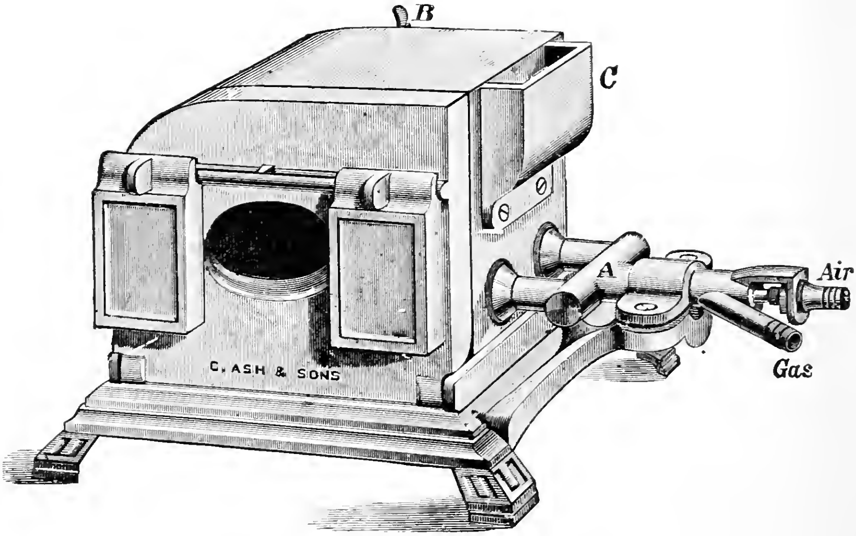
heated. The sulphate is decomposed by electrolysis, and more or less metallic copper is probably always deposited upon the plate, and remains under the teeth in inaccessible places after the denture is finished; hence the "coppery" taste sometimes complained of in newly-soldered dentures when first inserted. This may be remedied in the case of a gold denture by immersion in a weak solution of nitric acid and water; and if the denture is of silver—which metal would be acted upon by nitric acid—boiling in a strong solution of alum is recommended.

Where a fume closet with flue communicating with the outside air can be placed in the laboratory, it will be of great advantage in confining the vapors from pickling solutions and preventing their deleterious action upon the exposed steel instruments.

Porcelain Furnaces.—Furnaces for the fusing of porcelain for inlays, crown and bridge-work, and continuous-gum have of late years been improved to such an extent, and are in such general use, that it has been deemed wise to discuss them briefly in this chapter. They were originally placed in the dental laboratory for the baking of block teeth, single teeth, or for use with the continuous-gum process. They were exceedingly bulky, occupying so much space that they could not be placed in the smaller laboratories, required a high chimney for draught, and were

dirty and unsatisfactory in their working in most ways. Anthracite coal was used as the fuel, and as the furnace had to be charged for each burning the process required considerable time. The first important modification of the old-fashioned furnace was made by Dr. Ambler Tees, in 1880. He reduced the size of the apparatus, and decreased the time necessary to operate it. Coke was used as the fuel. Following upon this was the attempt to use gaseous or liquid instead of solid fuels, and furnaces after the patterns of C. H. Land, A. B. Verrier, and John H. Meyer were a great advance over the others. They economized time, were more easily heated up, and in general operated more satisfactorily than the solid fuel furnaces. These still failed to infallibly provide against the "gasing" of the porcelain, and a furnace designed by Downie by the use of a platinum muffle removed this danger com-

Fig. 82

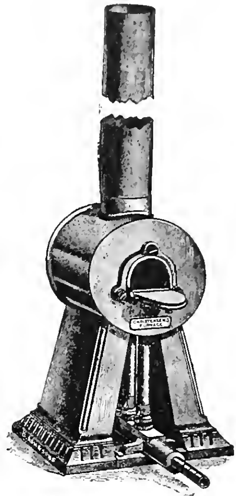


Ash's gas furnace for continuous gum work.

pletely. It was designed for baking crowns, inlays, gum sections, etc. A larger furnace operating by a similar principle and suitable for the baking of full dentures in high-fusing porcelain is shown in Fig. 82. It has a nickel muffle, and the danger of "gasing," which is a factor to be seriously considered in all coke and gas furnaces, is eliminated in this furnace because the muffle is carried through the fire-clay lining to the opening in the iron casing on either side. This arrangement is advantageous also in giving two means of entrance into the muffle, so that the piece being fired can be watched from both sides. The two openings to the muffle are closed by a double set of sliding doors, which are made of iron with a fire-clay lining of $\frac{1}{2}$ inch thickness. When it is necessary for the operator to look into the muffle the doors are slightly moved apart, so that only a minimum amount of heat escapes. The cooling can also be regulated better by opening first one side and then the other.

The Christensen draught gas furnace (Fig. 83) was one of the first to be used without an air blast. This, of course, meant a great saving in labor. especially where a foot-blower was in use. The roar which is such a drawback in gas furnaces is considerably lessened, but by no means done away with in this furnace. To get the highest temperature the gas must be so regulated as to obtain the greatest possible roar in the burner.

Fig 83

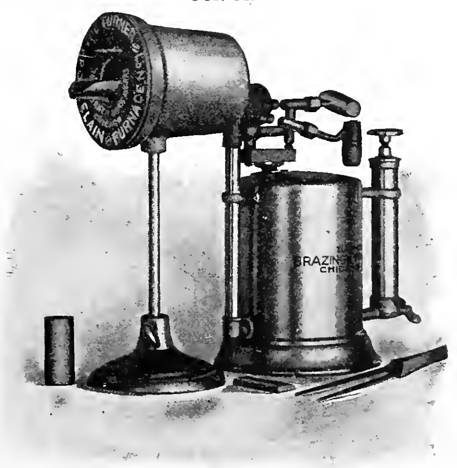


Christensen's Gas Furnace.

This furnace also has a nickel muffle 3 inches long, $1\frac{1}{4}$ inches high and $1\frac{1}{2}$ inches wide, which makes it useful for inlays, crowns, and small bridges. The draught is obtained by a chimney 18 inches high, being placed in the centre of the casing directly above the muffle. The three Bunsen burners which supply the heat are arranged in a row so that the flames envelope the muffle equally along the whole of its length, producing an even temperature inside the muffle.

Recently furnaces for fusing porcelain utilizing gasoline have been introduced. The temperature obtainable in them is sufficient to bake any of the most refractory porcelains, except block tooth-body, a temperature of 3000° being claimed as possible. The heater of the furnaces of the Turner Brass Works is of the blowpipe type, described on page 53, the furnace itself consisting of a cast-iron shell lined with fire-clay, with a seamless nickel muffle spun out of one piece of metal. (Figs.

Fig. 84.

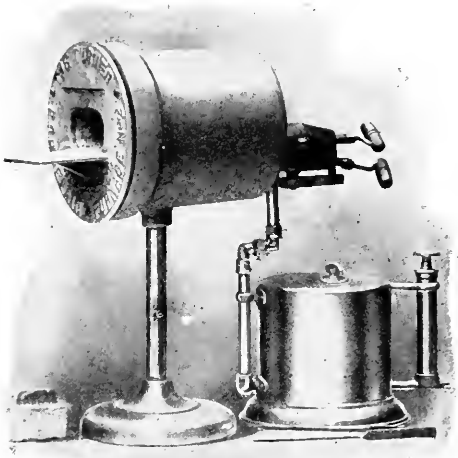


Gasoline furnace for inlays and crowns.

84 and 85.) The furnace designed by Dr. R. C. Brophy (Fig. 86) is somewhat similar in construction, having, however, a cast-iron seamless reservoir for the gasoline and being attached permanently to the

furnace. In these appliances the necessity for continuous blast with the foot-blower is done away with, and with proper care they are perfectly safe. The principal objection to be urged against them is that which obtains with the blast gas furnaces, and that is the noise of oper-

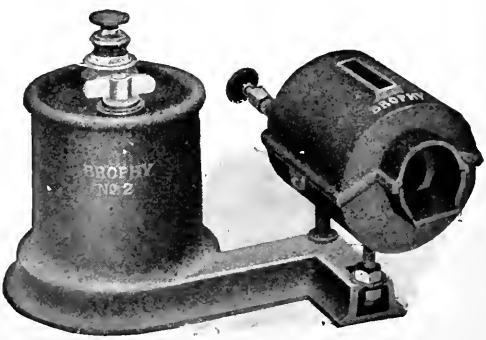
Fig. 85



Gasoline furnace for crowns and bridges.

ation, but when it is remembered that they may be used in any locality, as they are independent of gas or electric supply, and possess a high degree of efficiency, their value, especially to the country practitioner, at once becomes apparent, and the objection on the score of noise becomes relatively of no moment.

Fig. 86



Brophy's gasoline furnace.

Electric heat for the fusing of porcelain is now receiving extensive application, and the means of utilizing so valuable an agent for this purpose are constantly being improved. To Dr. L. E. Custer[1] belongs the honor of having first made a public demonstration of the method.

[1] October, 1894.

Heat is obtained from electricity according to the following principle: When an electric current meets with a marked degree of resistance in its circuit, heat is produced in the effort to overcome that resistance. Platinum which has relatively low electrical conductivity and has a high fusing point is introduced into circuit in the form of fine wire, the finer the wire and the greater its length the greater the resistance which it offers. As the platinum becomes heated its resistance is further increased, and the heat produced likewise increased, so that by a proper correlation of the size of the wire and its length with the voltage of the current, it is possible to attain a heat only limited by the fusing point of the platinum.

Electric heat possesses peculiar advantages for the fusing of porcelain. As it is not derived from combustion the products of the latter are absent, and the danger of "gasing" is removed. The appliance is also more cleanly and occupies less space and is more convenient to use for the same reason. The accuracy with which the heat may be controlled and regulated by a rheostat, and the cleanliness, simplicity, freedom from noise and odors, and efficiency of this method particularly recommend it in the laboratory.

The 110-volt direct current is the best for operating an electric furnace, this being usually the "power" current in cities. The 220-volt direct current may be reduced or used directly, the furnace having been specially wound for it, while 550 volts is too high to be admitted to a building. The 52-volt or 104-volt alternating current may be used, these necessitating also a specially wound furnace. The rheostat, which controls the heat produced by a given furnace on a circuit suitable to it, is simply a fixed resistance consisting usually of coils of German silver wire, varying amounts of which may be switched "in series" with the furnace. The greater the resistance, the less the current, and, therefore, the less the heat generated by the furnace.

The liability of the platinum wire "to burn out" has been the greatest drawback to full satisfaction in the use of this class of ovens. The difference between the melting point of high-fusing porcelains and the platinum wire from which the heat is radiated is very small, yet it is within that narrow margin that the electric oven operates. Improvements, however, have recently been made by Dr. Custer,[1] by which the danger of "burning out" has been almost entirely obviated, so that electric ovens have been subjected to from 800 to 1200 heatings without danger to the platinum wire. This result was effected by conforming the oven cavity more closely to the shape of the denture, and in making every inch of the interior walls heat-producing surfaces by bringing the wires to the surface so that but little fire-clay intervenes between the wire and the object heated. It was also found that an oven not spherical in shape would become hotter in the centre, even if the wires were placed the same distance apart all over the surface. This difficulty was avoided by beginning at the centre and arranging the wires closer together as the distance from the centre increased; by this means perfect uniformity of heat was secured. Dr. Custer observed that it was always the negative

[1] Abstract of paper read before the National Dental Association, Omaha, September, 1898. Ohio Dental Journal.

end of the platinum wire that burnt out, and that the negative end of a wire heated by a constant electric current becomes about one-fifth hotter than the positive end. He therefore determined to use thicker wire at the negative end, by which means he solved the most perplexing problem in the construction of electric ovens.

In his furnace (Fig. 87) the wire is placed in short curves to avoid great displacement from the expansion in the heating, and as it is near the surface great care should be exercised to prevent the fusing of portions

Fig. 87

The Custer electric oven No. 2.

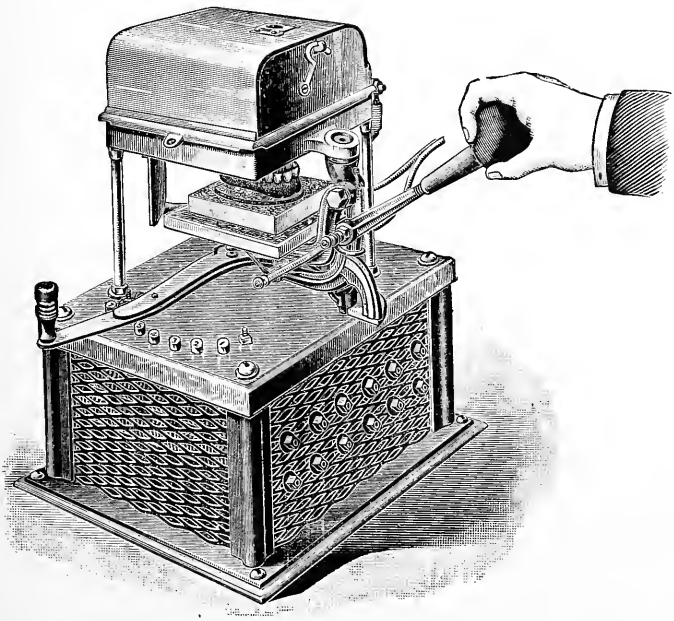
of porcelain upon it, and to prevent contact with a metallic instrument while heated as a "burn out" might result.

The procedure in the practical use of the oven is exceedingly simple. The case is placed on the tray in the lower section, and the upper is then closed down. The lever of the rheostat used with the furnace is placed on the first button, and heat for drying out the case is quickly obtained. When the operator is satisfied that there is no more moisture present he raises the heat by pushing the lever to the right. (See Chapter XVI.). If he allows two minutes to each button, it will require from twenty to twenty-five minutes to reach the fusing point. If it is a crown or bridge less time may be consumed in raising the heat without danger

to the case, and it may be fused in from ten to fifteen minutes by throwing the lever over more rapidly. When the desired temperature has been obtained and the fusing of the porcelain is completed, the lever of the rheostat is thrown back and the current cut off. At that instant the heat begins to go down, so that neither overfusing nor loss of brilliancy in the gum color can occur.

The "drop bottom" furnace designed by Mr. W. A. Hammond (Fig. 88) has found much favor with continuous-gum workers, because of the ability to lower the bottom of the furnace containing the denture for inspection during the heating process without materially lowering the heat of the oven. The Pelton furnace is of another type. In this an effort is made to utilize the heat generated in the rheostat, and ordinarily

Fig. 88



Hammond drop bottom furnace.

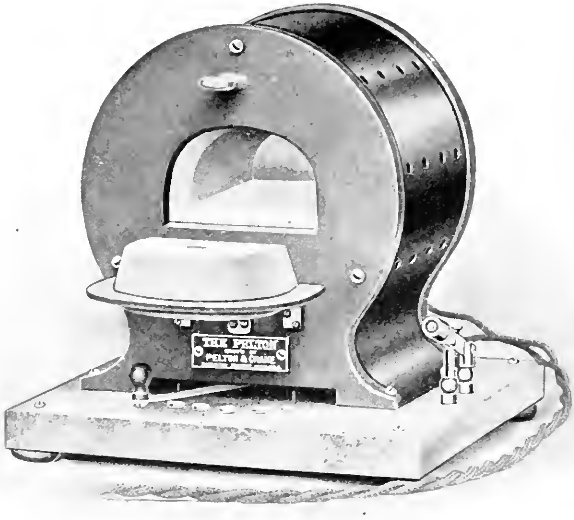
wasted, by winding the wires of that instrument about the furnace. Its form is shown in Fig. 89. Any of these furnaces may be used for crown work or for inlay work, as well as continuous-gum, but as they were specially designed for the latter work, they are rather too large for such delicate operations. Smaller sizes of them may be obtained for inlay and crown work. In addition to these, the Mitchell furnace No. 1 (Fig. 90) is a very simple one for making inlays and crowns. It requires no rheostat, the current required for it being obtainable from any existing lamp-socket. The wire is wound upon the outer side of the muffle, and so it is easy to repair, because the two ends of the broken wire may be easily seen when the muffle is removed.

[1]Every dentist who desires to make use of an electric furnace ought to

[1] Manuscript describing construction of furnace furnished by J. D. Hodgen.

understand the principles underlying its construction sufficiently well to be able to repair it. Repair is most often needed in the muffle;

Fig. 89



The Pelton Furnace.

Fig. 90

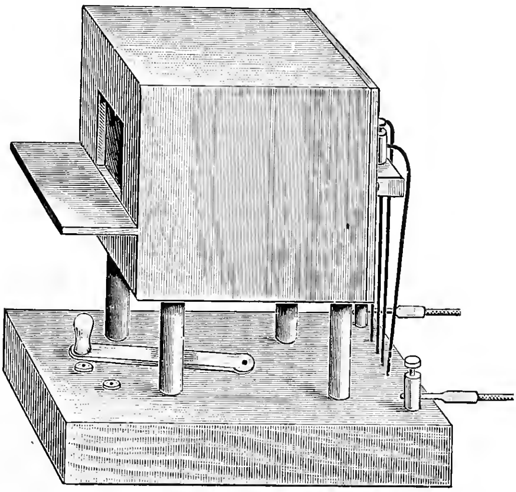
Mitchell furnace No. 1. (About half-size.)

therefore, simplicity of construction and ease of repair in this part of the furnace are most essential. The following is a description of a

very simple method of constructing an electric furnace for the fusion of porcelain. With such an appliance as this, heat necessary for the fusion of the most refractory bodies can be quickly obtained. It is suitable for use on a 110 volt direct current circuit.

Furnace Case.—Any rectangular or dome-top cast-brass, gun-metal or bronze case, $2\frac{3}{4}$ by $2\frac{3}{4}$ by 3 inches in width, depth, and length, respectively, will suffice (Fig. 91). The front end of the case should be provided with an opening or door the size of the open end of the muffle desired. For instance, for crown, bridge, or inlay work, it need not have an area greater than 1 square inch. Beneath the door a shelf flush with the bottom of the muffle and running the full width of the case and about 1 inch in width should be provided. The whole case, except the back, may be cast in one piece, if desired, as there is no occasion for removing any of the enclosing walls except the back end, which should be separate

FIG. 91



Dental electric furnace.

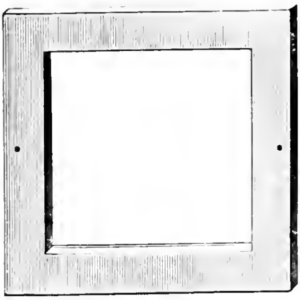
and secured in place by two or three screws. When it has been removed, the muffle may be adjusted, repaired, or replaced with very little trouble. The metal portion of the back need not be much more than half an inch wide (Fig. 92), which is sufficient to hold in place a fire-clay or soap-stone insulating refractory end piece (Fig. 93) which fits the end of the interior of the case, and through which the platinum wire terminals are conducted and properly connected outside of the case. A complete furnace of this character is shown in Fig. 91.

The furnace case may be supported on a soap-stone, marble, or other base, 4 by 5 by $\frac{3}{4}$ inches, by four metallic posts about $1\frac{1}{2}$ inches long. Copper wires about No. 14 gauge, leading to the buttons and switch, are laid in grooves cut in the under surface of the base (Fig. 95). The furnace is devised to carry a muffle in which a portion of the platinum wire in the muffle coil is cut out of circuit by the switch below, thus obviating the necessity of a rheostat, the principle of which arrangement will be explained further on.

The muffle is made in the following manner: A form of core (Fig. 96), about 5 inches in length, is made of soft wood, tapering very slightly from end to end, so that the circumferential measurement is sufficiently less at one end than the other to admit of the core being withdrawn from the finished muffle made about it without breaking or distorting the fragile case.

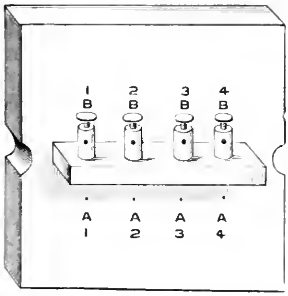
The form is first covered with two pieces of smooth, heavy writing paper (Fig. 97), each piece of which extends nearly around the form, the ends of one piece overlapping those of the other, and both held in position by pins. This done, the form is ready to be wound with the platinum wire.

Fig. 92



Metal frame for back of furnace.

Fig. 93



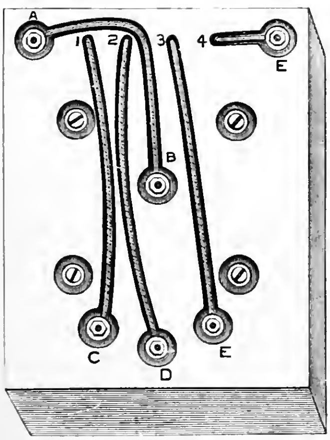
Fire-clay back of furnace: A, for exit of platinum wire terminals; B, binding posts for copper wires.

Fig. 94

Binding post. Upside down.

About 16 feet of No. 30 gauge, pure, perfect platinum wire having been provided is first well annealed, preferably in an electric oven, and two pieces of not more than 6 inches each cut off of one end, thus leaving a piece of wire about 15 feet in length. About 18 inches from the first end of the long piece of wire, one of the 6-inch pieces is securely and neatly attached; 18 inches farther on (36 inches from the end of the long wire) the second 6-inch piece is in like manner attached. This done, the wire for the muffle, as a whole, presents four ends and is ready for winding. The first end of the long wire is made secure around one of the pins on the small end of the form (Fig. 97), leaving about 6 inches as a terminal. The wire is wound about the form, not tightly, but firmly, so as to keep its place, with coils about a millimetre apart, leaving about 6 inches of the last end of the long wire unwound and drawn under the last coil to hold it securely and to become another terminal (Fig. 97).

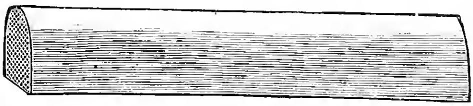
Fig. 95



Bottom of the base showing the wiring.

A mixture of fire-clay, one part, and ground fire-brick,[1] one part, is now made into a pasty mass with water and thinly painted over the wire on the form with a soft brush. This is dried over a Bunsen burner flame and another coat added and dried in the same way, and so on, until the muffle is about $\frac{3}{16}$ of an inch in thickness. The whole is then dried thoroughly. Avoid applying the mixture too thick each time before drying, or the muffle will crack badly and these cracks will be difficult

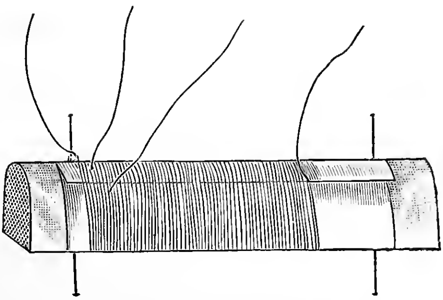
Fig. 96



Wooden form for making muffle.

to fill. When the muffle is made sufficiently thick to give proper rigidity (Fig. 98) and well dried, carefully withdraw the pins, catch the muffle firmly in the left hand, and with a hammer strike the small end of the wooden form a sharp blow. This will drive the form out of the muffle, after which the papers can be easily removed. The muffle now presents the appearance of Fig. 99, with the four end wires protruding from the clay encasement. A thin mixture of the clay and fire-brick can now

Fig. 97



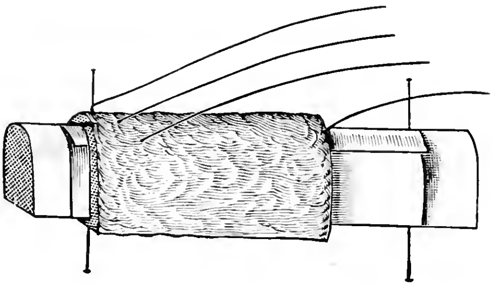
Form with paper wrapper and wire wound.

be taken on the brush and painted over the wire coils on the inside of the muffle, so as to barely cover them and fill in any inequalities of the surface. This being done and the muffle again dried, its uneven ends are trimmed smooth and the wire ends laid from the front end back along the muffle, so as not to come in contact with each other, and held in the desired position by a thread tied around the muffle (Fig. 99). The muffle may now be placed in position in the furnace case, with the front end as nearly flush as possible with the door of the case. A thick asbestos board should be placed between the bottom of the muffle and the floor of the furnace case to support the muffle, and asbestos fibre

[1] It is probably better to secure an old fire-brick that has been repeatedly burned in use, grind it up, not too finely, and pass a magnet through the mass to abstract any iron that may be present. Silex, three parts and fire-clay, one part may be used, but the old fire-brick is considered preferable

packed all around between the muffle and the furnace case to hold the former firmly in position. Finally, a piece of asbestos board large enough to close the end should be adjusted over the back end of the muffle, and the four end wires carried around the asbestos board and threaded through the holes, *A*, Fig. 93, in the soap-stone or baked clay back, in proper order: Thread the first end of the long wire through hole 1, the first attached 6 inches through hole 2, the second attached 6 inches through hole 3, then the second end of the long wire through hole 4. The soap-stone or baked clay back being set in position, the end casting of the furnace case may be secured and the platinum end wires made

Fig. 98

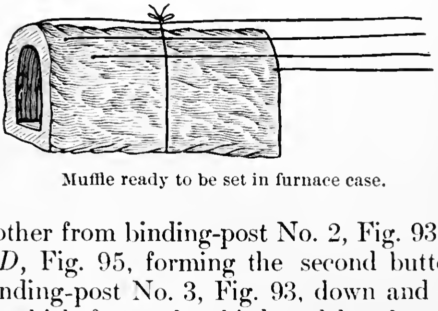


Muffle ready to be removed from form.

fast to the under end screws of the binding-posts, *C*, Fig. 94, bearing the same number on the soap-stone or clay back.

A copper wire (No. 14 gauge) is now led from the terminal post, *A*, Fig. 95, along a groove in the bottom of the stone base of the furnace, to the binding-post *B*, which carries the key of the switch. Another copper wire of the same size is carried from binding-post No. 1, Fig. 93, of the baked clay back, down through a hole in the base, No. 1, Fig. 95, and along a groove to binding-post *C*, which forms the first button of

Fig. 99



Muffle ready to be set in furnace case.

the switch. Another from binding-post No. 2, Fig. 93, down and along to binding-post *D*, Fig. 95, forming the second button of the switch. Another from binding-post No. 3, Fig. 93, down and along to binding-post *E*, Fig. 95, which forms the third and last button of the switch. Still another copper wire of the same size is carried from binding-post No. 4, Fig. 93, down through hole No. 4 in the base, Fig. 95, to binding post *F*, which forms a terminal.

These wires all properly adjusted, the furnace may be connected with

the current (Fig. 91), and the key of the switch placed on button No. 1, for a few seconds at a time, until the new muffle is dried, or, better, leave the key of the switch on button No. 1 and give the muffle the current from the connecting wall switch. After the muffle is perfectly dry, the switch key may be moved to buttons No. 2 and No. 3, thus raising the muffle to its maximum heat.

The rationale of this method of wiring is: When the key is on button No. 1, the current is carried through the whole wire of the muffle (about fourteen feet) and is too little to perfectly heat this amount of wire; it is changed to button No. 2 and passes through eighteen inches less of wire and a greater heat is exhibited; finally, on button No. 3 the current passes through eighteen inches less (about eleven feet) of wire and furnishes somewhere near the maximum heat.

Should the muffle fail at any time to heat up, the failure is probably due to the platinum wire having been broken at some point. If this "burn-out" occurs in the first eighteen inches of the coil, the furnace will heat up from the second button; if in the first thirty-six inches of the coil, it will heat up from the third button; if back of this, the furnace will not heat up at all. By removing the muffle, the burn-out may be located. Raise the broken ends out of the clay and carefully twist them together, using no metallic instruments; make a hole in the clay and press the ends in it, then cover with a little clay, replace the muffle and it will heat up as before.

After considerable use, especially at the maximum heat, the platinum wire in the muffle seems to undergo some molecular change, perhaps a crystallization, which prevents its exhibiting as great a heat as when first placed in the muffle. It is then more economical to take out the old muffle and substitute a new one.

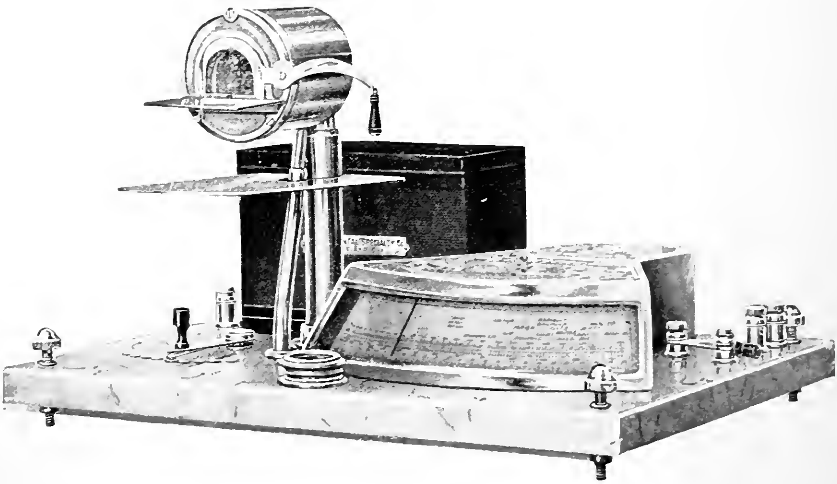
The proper fusing of porcelain is an operation of extreme delicacy, and requires nice precision in the adjustment of the temperature and time of baking which is necessary for each kind of porcelain used. Too rapid heating causes the porcelain to crack and check, while overheating causes generally a burning out of the color, and sometimes a porous condition due to the formation of gas in the mass. Underfused porcelain is darker in color, and not so translucent as that which is properly baked, and it is usually granular on the surface. If the porcelain is brittle after it is fused, this probably means that it was cooled too rapidly —did not get the temper of slow cooling. If it shows a pale bluish-white color with its porcelain filled with bubbles, this indicates "gasing," or contact with some of the products of combustion through a leaking muffle.

In using the older furnaces the workman had to depend solely upon visual judgment in determining when the porcelain was properly fused. Some made use of a pellet of pure gold, in working with the high-fusing bodies, placing it in the muffle and keeping the piece of work in the heat a definite time after the gold was seen to fuse (2012° F.). This principle is utilized by Le Cron in his pyrometer, in which by varying the proportions of gold and platinum in the pellet the temperature of any given one of the high-fusing bodies may be judged, and, having been determined, the body may be baked at that temperature.

To Dr. W. A. Price,[1] of Cleveland, Ohio, belongs the credit of placing the first dental pyrometer on the market. The pyrometer designed by Dr. Price depends upon the principle of the thermopile. When certain metals in contact are subjected to heat an electric current is generated, the quantity of which depends upon the temperature to which these metals are subjected, increase in the temperature causing a corresponding increase in the quantity of current given off. A small pellet of the metal rhodium is welded to two platinum wires, and one or more of these miniature thermopiles are introduced in the rear of the muffle. When they are heated a feeble current is generated. As the temperature increases the quantity of current in a like manner increases and this is measured by means of a delicate milammeter.

The pyrometer designed by N. K. Garhart, of Indianapolis, Indiana, depends upon an entirely different principle. He interposes in the current of a low voltage circuit a "Nernst Glower," and measures the

Fig. 100



Price furnace and pyrometer.

quantity of current passing through the "glower" by means of a delicate milammeter. The "Nernst Glower" is a peculiar variety of porcelain which is a non-conductor when cold, but a conductor when heated. The conductivity of the "glower" is in ratio to the increased temperature of the muffle. The amount of current required for the "glower" undergoes no change from its repeated use. The current is obtained from the street circuit on the shunt plan, and owing to the minute amount required for this purpose slight fluctuations of the street supply current do not in any way impair the accuracy of the instrument.

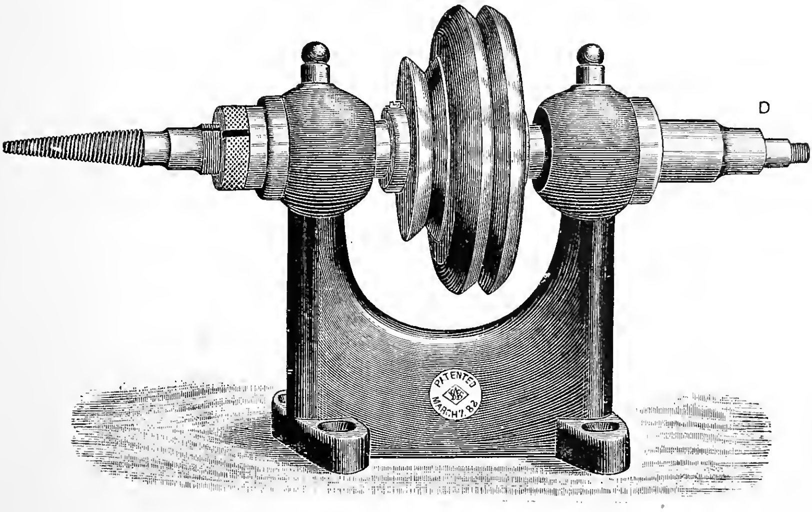
Lathes.—For grinding and fitting teeth a light, easy-running lathe,

[1] J. Q. Byram, The International Dental Journal, vol. xxvi, p. 509.

with a substantial frame of iron or wood 2 feet 11 inches high to the centre of the pulley head, which will permit the operator to sit while at work, should be provided. The sitting position saves him from much of the fatigue occasioned by continuous work of this kind, while it affords the steadiness to the body and hands which is demanded by the delicate and precise work of fitting teeth to gold or silver plates and to each other.

The centre of the pulley head should be not less than 4 inches from the top of the lathe table, which should be formed of ash or cherry wood 26 inches long by 20 inches wide and $1\frac{5}{8}$ inches thick. The frame may be made of oak or ash wood securely fastened together, or a lathe

Fig. 101



Unique lathe-head.

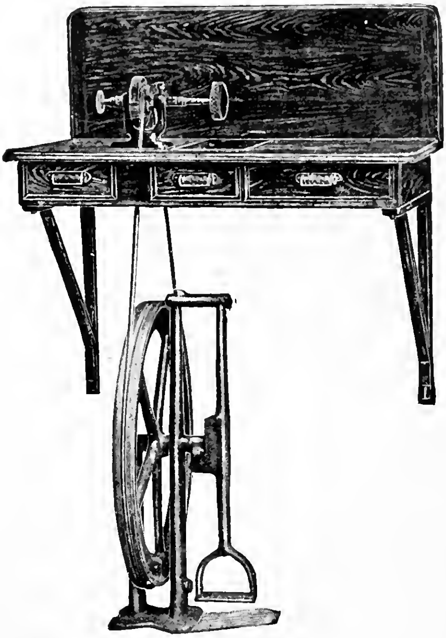
table similar to the one in Fig. 102 may be used. It occupies little space, is provided with two drawers to hold the grinding wheels and polishing powder carriers, and has a middle drawer lined with galvanized iron which catches the waste from the lathe through the opening in the top of the table.

Many of the lathes offered for sale at the dental depots are not entirely satisfactory either for fitting teeth or polishing. Their driving wheels are either too heavy or too light. Figs. 101 and 102 illustrate a lathe-head and driving wheel of recent introduction, which will doubtless answer all requirements of the dental laboratory. Fig. 103 shows a sectional view of the lathe-head; Fig. 104, a set of chucks for mounting corundum wheels and polishing brushes, etc.; Fig. 105, a reamer for fitting wheels having wooden centres to taper screw-chucks.

A lathe intended for fitting teeth does not require great speed or much power. A good lathe may be made by obtaining the frame and driving wheel of one of the inexpensive forms of amateur turning lathes now in the market, and adjusting a Lawrence head to it. The working

parts of the lathe should be kept clean, well oiled, and protected as far as possible from abrading powders and other gritty particles with which it is constantly surrounded. In perhaps the majority of dental labora-

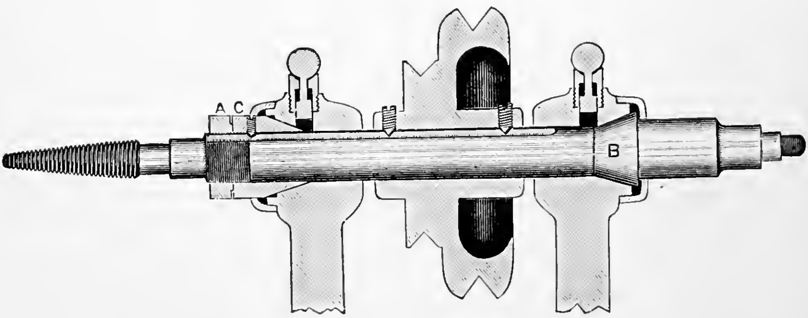
Fig. 102



Lathe table and driving wheel.

tories but one lathe is used for all purposes of grinding and polishing. It is much better, however, to have a larger and stronger lathe for polishing purposes exclusively, and, as greater speed is required for this pur-

Fig. 103

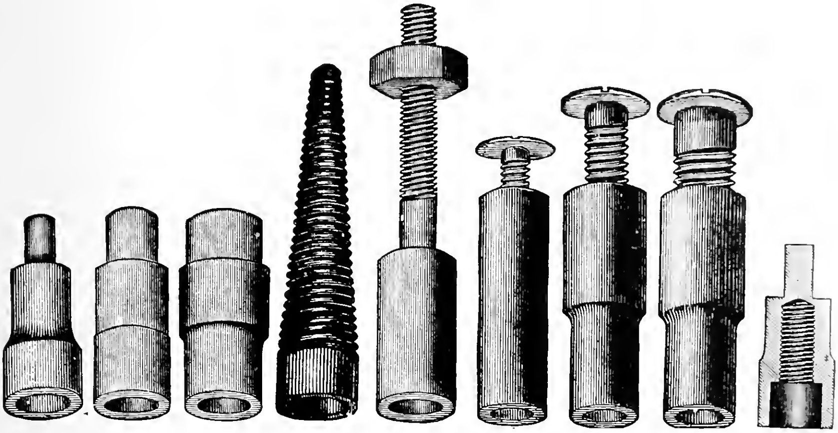


Section through unique lathe-head.

pose, it should be about 3 feet 10 inches in height to the centre of the pulley head, so that the operator may stand while using it; the form of lathe head shown by Fig. 107 will answer admirably. The fly-wheel

should be at least 20 inches in diameter, and should weigh about 35 pounds. The treadle should be operated by a lever or leg motion, and not by what is known as the heel-and-toe treadle, which does not afford

Fig. 104

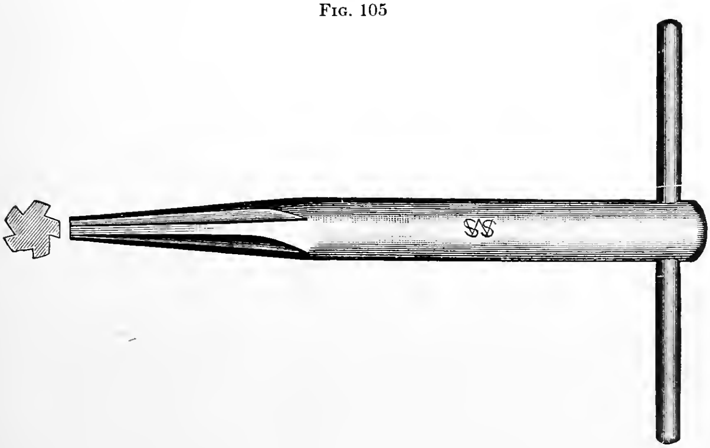


Chucks for unique lathe-head.

sufficient speed or power. The lift of the treadle should be not less than $2\frac{1}{2}$ inches.

One of the most valuable applications of electricity to the needs of the dentist is in the running of laboratory lathes, and, when supplied with the 110-volt direct current, such an apparatus is by far the most convenient and effective lathe used for the purpose of fitting teeth or

Fig. 105



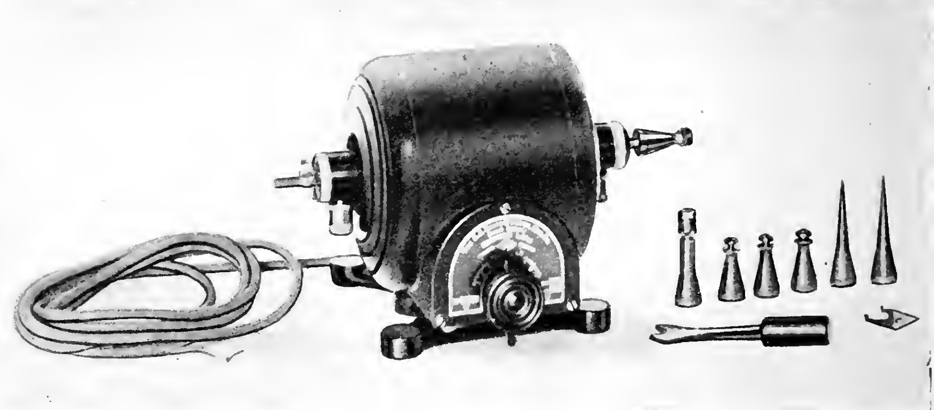
Reamer for brush-wheels.

polishing dentures. In the last few years thoroughly satisfactory lathes have been manufactured also for the alternating current, but the direct current is preferable as a source of power.

As shown by Fig. 106, we have an electric lathe which is admirably adapted to either general laboratory uses or as an office lathe for the

fitting of porcelain crowns or the adjustment of the articulation of artificial dentures. Its bearings are completely protected from dust by the japanned iron jacket which covers the armature. It is noiseless, and is constructed with such precision that its motion is hardly perceptible. It is adapted for the 110-volt current, and the author has found that it possesses more than sufficient power for all purposes required by the dentist. As no special table is required for this motor, it may be placed in any convenient position. It may be run in either direction.

Fig. 106.



S. S. White electric lathe.

It has a range of speed varying from 1000 to 4000 revolutions per minute, and the torque, or pull, is as great at the lowest speed as at the highest.

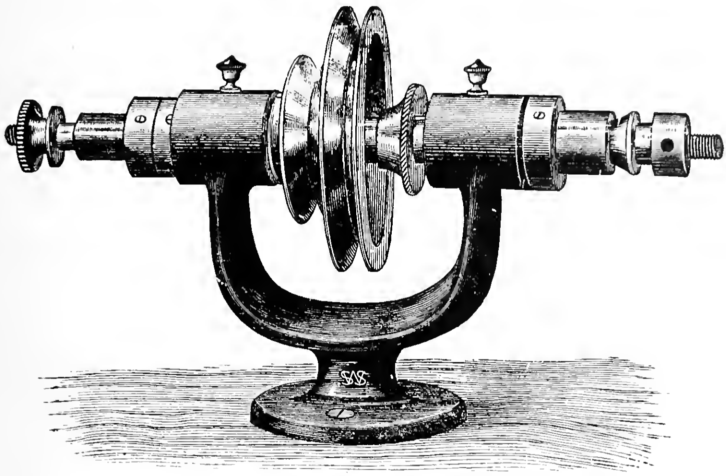
The regulation of speed and the starting and stopping of the lathe are effected by a slight turn of the milled stud shown in the cut. The chucks are fixed on the tapered ends of the spindle by a light tap, with any metal tool which may be conveniently at hand, and can be instantly removed while revolving or stationary by the tool shown below the chucks, used as a lever to force the chuck off the end of the spindle.

The polishing lathe should be provided with a drawer for the safe keeping of mandrels, brush wheels, felt and cotton wheels, cones, etc., together with the abrading and polishing powders which are usually employed in the final finishing of the different kinds of prosthetic pieces. Corundum wheels, spatulas, cements, etc., used in fitting and attaching teeth to the plate, should be kept in a drawer attached to the grinding and fitting lathe.

The corundum wheels so extensively used in the dental laboratory are made of the mineral corundum found in Ceylon and in Pennsylvania, Georgia, Massachusetts, and North Carolina. It occurs in crystals of the form of double six-sided pyramids of various sizes, and in some localities in large masses without crystalline form. Corundum is an aluminum oxide having the formula Al_2O_3. The ruby and sapphire are transparent

varieties of this mineral, their color being due to the presence of a small amount of coloring oxides. Emery, the use of which preceded

FIG. 107



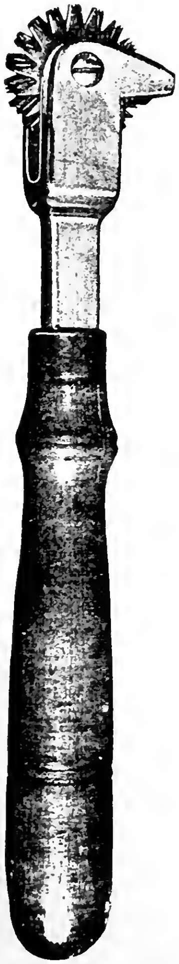
Lathe-head suitable for polishing lathe.

corundum as an abrasive agent in the dental laboratory, is a coarse variety of corundum. Corundum is, with the single exception of the diamond, the hardest mineral known. It is prepared by pulverizing the crystals in an iron mortar by successive blows of a heavy steel pestle. The three grits which are employed in making wheels for dental purposes are obtained by passing the powdered corundum through sieves of different degrees of fineness; they are known as fine, medium, and coarse. The latter will cut most rapidly; the finest will not cut so fast, but will leave a much finer surface. The powdered corundum is mixed with finely ground gum shellac in the proportions of 3 ounces of corundum to 1 of shellac; this is carefully heated and thoroughly mixed until it becomes of a doughy consistence, when it is put into an iron mold made in two parts, previously oiled. This mold is placed in a small press and force enough applied to consolidate and distribute the mixture into all parts of the mold. Too much force should be avoided, as it is liable to drive out so much of the shellac that the particles of corundum will not be sufficiently adherent—a condition which will greatly lessen the wearing qualities of the wheel. After the wheel has been removed from the mold, which is done by tapping the latter sharply with a wooden mallet, it is washed in alcohol for the purpose of removing the shellac from the surface and leaving the wheel in a sharp or gritty condition.

Carborundum wheels, which are also in general use for grinding purposes, have as their abrasive constituent "carborundum," or the carbide of silicon. This substance was made experimentally in 1893 by Mr. G. E. Acheson, and is now manufactured on an extensive scale at Niagara Falls, where large amounts of electricity are economically available, the intense heat of the electric furnace being necessary to

produce the combination of the carbon and silicon. Carbon in the form of finely divided coke, silica as very pure and clean sand, common salt ($NaCl$), and sawdust mixed together in definite proportions constitute the charge for the furnace. This is built of brick about 16 feet long by 6 feet wide and 4 feet high. It is packed with the charge up to the level of the electrodes, which enter it about the centre of each end, and a core of crushed coke is laid from one electrode to the other. The remainder of the charge is then put in and piled up to a height of about 8 feet. The current is then turned on. About 1000 horse-power of energy is utilized at an average voltage of 185, and a temperature approximating 7500° F. is reached. The burning takes thirty-six hours, the sawdust burning out and rendering the mass porous for the escape of carbon monoxide and other gaseous products. A mass of crystals is formed around the core, which consists of carbide of silicon (CSi), the carbon and silicon having combined in atomic proportions. These crystals are crushed, treated to a bath of dilute sulphuric acid, washed, and sieved. The wheels are made of the various sizes of crystals mixed with feldspar and kaolin, which constitute the "bond." They are molded into shape under tremendous pressure and baked in a kiln for seven days. Carborundum is harder than corundum and is more brittle. Wheels made of it may be run as well wet as dry and will not clog. They do, however, wear unevenly, probably due to lack of homogeneity of the bond or its uneven baking. Frequent tooling with the dresser shown in Fig. 108 will keep them true.

Fig. 108.



Dresser for rendering worn carborundum wheels true.

While grinding porcelain teeth the corundum wheel must be kept constantly wet to prevent the shellac from becoming heated by friction—a condition which instantly impairs its cutting properties. Numerous appliances have been devised in the form of "drip cups," designed to automatically supply sufficient water to the wheel while in use to prevent heating; but these are objectionable in more than one respect, and are liable to obstruct the light and prevent it from directly falling upon the point of contact of the tooth with the wheel. A simple dish, oblong in form, with the dimensions of 8 inches in length by 5 inches wide, by $2\frac{1}{2}$ in depth, partially filled with clean water, serves as a good hand-rest, while a piece of sponge of the size of a large walnut, which the operator will soon acquire the habit of holding between the index and middle finger of the right hand while he keeps it in contact with the corundum wheel, is an excellent means of conveying water to the wheel and preventing it from splashing his face or clothing.

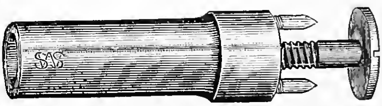
There are at least seven sizes of corundum wheels made for dental laboratory purposes, ranging from $\frac{3}{4}$ of an inch in diameter to $3\frac{1}{8}$ inches, but the author has found, after much experience in fitting carved blocks, rubber sections, and single-gum teeth, that a maximum of 1 inch in diameter and $\frac{1}{6}$ of an inch in thickness is quite large enough for jointing purposes, while the smaller sizes, which are indispensable, are obtained by the wearing away of the 1-inch wheels.

In finishing dentures the first step is the proper levelling of the surface; this is usually done in metallic cases with the corundum wheel, after which the scratches left by the sharp particles of corundum should be removed by a keen-edged vulcanite scraper. The piece is then ready for the "Scotch stone," a soft mottled stone much used by silversmiths and workers in the precious metals, furnished by the dental-supply houses in pieces of 6 inches in length by $\frac{1}{4}$ inch in thickness. This material has decided abrasive qualities, and is used chiefly to remove the scratches left by the corundum wheel and scraper; it produces a fine silk-like surface and brings the case to the point where the buff wheels armed with the coarser powders, such as pumice, are to be used; these produce a surface which may be highly polished by the brushes which should follow the buff wheels, and should carry the finer polishing powders or those used for the purpose of obtaining high lustre, such as calcined buckhorn when the case is of gold or silver, and prepared chalk when it is of vulcanite or celluloid.

In vulcanite or celluloid work the corundum wheel need not be used, the scraper being sufficient for the levelling of the surface, after which the finer numbers of emery paper, Nos. 0 and $\frac{1}{2}$, are employed, until all traces of the scraper are removed, when it is ready for the pumice powder, which is generally applied with a small stick of soft wood, such as poplar or pine, after which the denture is ready for the felt or other kind of buff wheel and fine pumice.

Buff wheels and cones are made of felt, cotton, duck, leather, soft wood, cork, disks of cloth or chamois leather, stitched together, etc. Felt is probably the best of the various materials used in forming buff wheels; these wheels can be obtained at the dental depots in sizes ranging from $1\frac{1}{8}$ to $2\frac{1}{2}$ inches in diameter. Buff wheels are intended to cut and not to polish. They are usually armed with pumice, and must be kept constantly wet while in use. The best size of buff wheel for dental-laboratory use is $1\frac{5}{8}$ inches in diameter by $\frac{3}{8}$ of an inch in thickness. Smaller sizes are obtained by the wearing away of the larger wheels. They are easily mounted upon the "screw-cone" mandrel, to which they do not ordinarily require to be cemented or shellacked. An ingenious felt wheel-chuck has been suggested by Dr. F. E. Pomroy; it is provided with three steel pins to prevent the wheel from revolving on the screw (Fig. 109).

FIG. 109

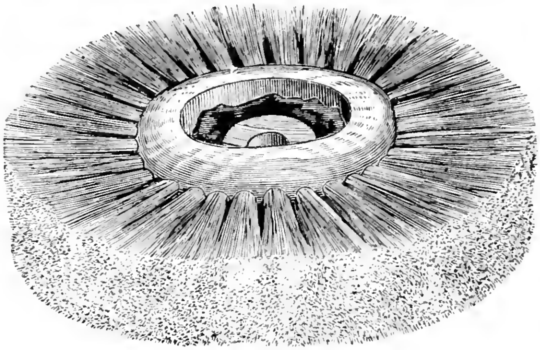


Felt wheel-chuck.

The brush wheel is employed for the purpose of obtaining a still finer surface than is attainable with the Scotch stone or buff wheel and for

the final polishing. There is quite a variety of forms made for dental laboratory use, beginning with the wood-centre brush wheel with straight

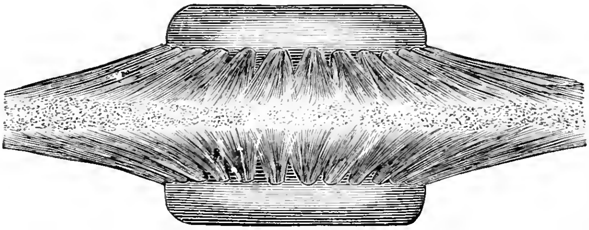
Fig. 110



Brush wheel.

bristles in from one to four rows (Fig. 110); the brush wheel with converging bristles (Fig. 111); the cup-shaped wheel with from one to four

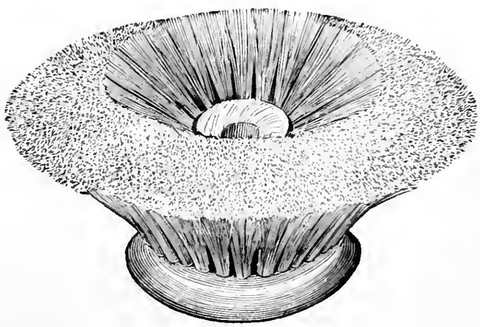
Fig. 111



Brush wheel; converging bristles.

rows of bristles (Fig. 112); cup-shaped bristles with long wooden shanks; hub-shaped with straight bristles and hub-shaped with converging

Fig. 112

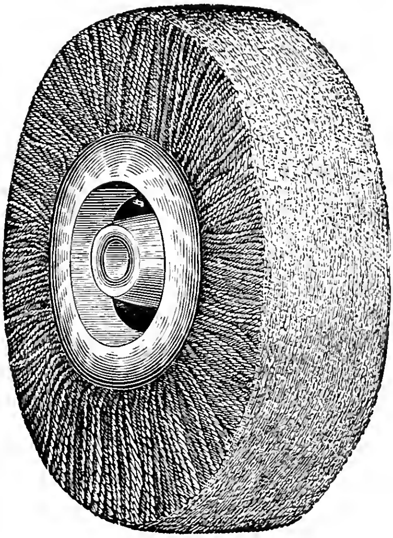


Cup-shaped brush wheel.

bristles, etc. In selecting brushes it should be remembered that those with coarse bristles are to be employed with abrading powders of the

class to which pumice belongs, while those with soft bristles are particularly adapted for use with prepared chalk, rouge, calcined buckhorn, etc., or wherever a high lustre is to be attained. Two brushes of each of the Nos. 1, 2, and 3, one coarse and the other soft, with three rows of bristles, are sufficient for finishing entire or partial dentures, with the addition of two small straight brush wheels of $1\frac{1}{2}$ inches in diameter, with two rows of bristles, for finishing places in the denture which will be found inaccessible to the larger wheels and for polishing crown and bridge-work. A wood-centre cotton wheel is a very efficient carrier for the polishing powders in the last stage of finishing (Fig. 113).

Fig. 113



Cotton wheel.

Finishing Powders.—Finishing powders are divided into two classes, used under different conditions and serving different purposes. The following partial list gives a few of those in general use:

Cutting powders:	Pumice, Emery, Corundum flour, Arkansas powder, Hindostan-stone powder, Tripoli,	used with a lubricant
Polishing powders:	Calcined buckhorn, Rotten stone, Prepared chalk, Rouge,	used comparatively dry.

Emery with oil has long been used by workers in the precious metals for cutting down the surface of gold and silver preparatory to the final polishing, but, as it is nearly black and liable to discolor the joints of the teeth, it is an objectionable mixture to employ in the finishing of

artificial dentures; hence its place has almost entirely been taken by pumice powder, with Castile soap and water as the lubricant. Emery is perhaps better suited for finishing continuous-gum cases, which, having no joints, are not liable to the same danger of discoloration as are dentures formed of single-gum teeth; platinum, of which the plates of this kind of dentures are made, resists attrition to a greater extent than does gold or silver; it therefore requires a more decidedly abrasive powder than would suffice for either of those metals to produce smoothness enough for the final polishing.

Of the polishing powders properly so called, calcined buckhorn has been found of so much value as an agent in the production of high lustre in gold and silver work that it has almost entirely superseded the use of the burnisher. It is applied with a soft-bristle brush wheel, similar to Fig. 113, revolving at the highest speed attainable. The powder is at first slightly moistened with water, but as the lustre appears it is taken up between the tips of the fingers and dropped in a perfectly dry condition upon the plate.

Rotten stone is also an excellent polishing powder, but, like emery, it is liable to discolor the joints and to find its way behind the backings in soldered work, and effect more or less change in the color of the teeth. It has, therefore, nearly gone out of use as a polishing material in the dental laboratory.

Prepared chalk is as effective an agent in polishing vulcanite and celluloid work as buckhorn is with the precious metals. It is also applied mixed sparingly, at first, with water, or preferably alcohol, on a No. 3 soft-bristle brush wheel until a high polish begins to appear, when it is dropped in a quite dry state upon the plate while in contact with the rapidly revolving brush wheel.

There is always some danger of heating vulcanite plates if held with force against a rapidly revolving brush wheel; the frequent unaccountable warping of vulcanite dentures may possibly be due to this cause; such an accident, however, need not occur if ordinary care is observed in allowing merely the ends of the bristles to come lightly in contact with the plate.

Rouge is a valuable polishing powder for gold and silver, and is much used by jewellers. It is moistened with alcohol and applied sparingly to a cotton buff wheel running at high speed. Care should be taken to keep it from the joints in single-gum teeth dentures, as its removal is a matter of some difficulty. Calcined buckhorn has to a considerable extent superseded it on account of its greater cleanliness.

The use of the burnisher as a means of obtaining high lustre in metallic dentures has been almost entirely abandoned, because of its tendency to spring or warp metallic objects to which it is applied, and of the fact that it is unnecessary.

Adhesive Wax.—Rosin-and-wax cement, as it is sometimes called—which is used for the purpose of uniting parts of work preparatory to its investment for soldering, such, for instance, as a clasp to a plate when it is necessary to maintain the precise relation of one to the other

until permanently fixed by soldering, and for temporarily fastening teeth to plates while arranging and adjusting them to the mouth—is an indispensable adjunct to the dentist's work-bench and lathe. Adhesive wax is usually composed of rosin 3 ounces, wax 1 ounce. The proportions vary with the season, the quantity of wax being reduced to half an ounce for use in hot weather or when the "cement" is found to be too plastic and yielding for satisfactory use. Mastic and dammar are also occasionally added to the above formula for the purpose of stiffening the wax. To prepare the cement, melt the rosin and wax in a suitable vessel, and stir until the two are thoroughly mixed; test pieces should be drawn out into sticks and allowed to chill, when, if found to be but slightly brittle and of sufficient toughness to hold a porcelain tooth or clasp in their correct relation to the plate while being removed from the plaster cast, the cement may be poured into a vessel of cold water, and when cool enough to handle, but still somewhat plastic, it is to be worked into sticks of about the size of an ordinary lead-pencil. These are allowed to become quite cold, dusted with dry plaster to prevent them from adhering, and laid away in a box for future use.

Rosin-and-wax cement is greatly improved by age; it is therefore a good plan to keep on hand a considerable quantity of it. Shellac rolled into rods and sealing-wax are often of value when used to reinforce the adhesive wax when temporarily attaching teeth and clasps to plates previous to investing for soldering. If the cement shows the slightest tendency to yield, a small quantity of shellac or sealing wax dropped upon it will so stiffen it that the denture may be removed from the cast without change of relation between the plate and the clasps or teeth.

Fluxed Wax.—This preparation, suggested by Dr. Parr for attaching clamps and teeth in plate and bridge-work, is put up in boxes and is applied with a hot spatula. It is said to set quickly and to hold the teeth and clasps firmly for trial in the mouth and during subsequent soldering. The "cement" throughout which the flux is distributed is readily burned or melted out, leaving the flux (probably finely powdered glass of borax) as a deposit over the crevices and surfaces to be joined, ready to perform its office in soldering. Experts in crown and bridge work seem to prefer to use the rosin-and-wax cement in bulk, from which it is taken up and applied with a hot spatula.

Sticks of plain wax are also very useful in "waxing up" vulcanite and celluloid cases; these may be made of the waste wax which is always found in plentiful quantity about the office and laboratory.

Sheet wax plays an important part in the preparation of artificial dentures on bases of fusible alloys, vulcanite, and celluloid, and for additions and modifications of the plaster cast preparatory to molding for the zinc die. The ordinary base plate supplied by the dental depots is generally too thick for the temporary plate of either of the cast or plastic bases. It may be safely said that much of the uncertainty of dental laboratory manipulations with these materials is due to a want of care in the preliminary arrangement of the wax. For some unaccountable

reason, the majority of mechanical dentists seem to think it necessary to make the wax plate two or three times as thick as the denture should be when finished, and after the vulcanizing to reduce it to the proper thickness with steel burs sold for the purpose, and which, on account of the danger when they are used of cutting through the plate, should have no place in the dental laboratory. The preliminary waxing of dentures of this class should be done with such care and precision that the waxed piece will represent not only the exact thickness of the plate when finished, but all the irregularities of surface which are found on the plaster cast. The rugæ and other prominences of the mouth assist in enunciation and mastication, and should be represented in the plate. It is probable that when so arranged artificial dentures feel less like foreign objects when worn in the mouth. In order not to obliterate these natural irregularities of surface the waxing may be done with two or three layers of wax, not much thicker than is used in making artificial flowers, laid on separately and pressed with the thumb, after being slightly softened in the flame of a spirit lamp or Bunsen burner, until in complete contact with the palatal portion of the cast. Any desired thickness can be obtained by additional sheets of wax, but the main point to be gained by this method of waxing is uniformity of thickness; and if the waxing is artistically done, little or no scraping or finishing will be needed after vulcanizing except at the edges. Indeed, the most skilful workers in the plastic bases have demonstrated that the best results in vulcanite and celluloid work are obtained by precision in waxing and the use of tin to prevent contact with the plaster of the investment, and to afford a polished surface which shall need but little alteration by the scraper. Sheet wax should not be over $\frac{1}{32}$ inch in thickness; it may be prepared by dipping a square piece of plate glass or hard wood $\frac{1}{2}$ inch thick, previously oiled, into melted wax, allowing it to cool upon the slab, and repeating the dipping until the desired thickness is attained, after which it is stripped off, trimmed to the dimensions of 3 inches square, laid in a box with tissue paper between the sheets, and it is then ready for use.

Bench Tools, etc.—The special application of tools will be found in the respective chapters devoted to the particular kinds of work in which each is used. Our remarks here will, therefore, be confined to their care and proper use. There are two infallible indications of the amount of training and skill possessed by a mechanical dentist: (1) the condition of his tools; (2) the state of the cast after he has made a denture upon it. Skilful and accurate workmen will do so little damage to plaster casts while constructing plates or clasps that little or no evidence of their having been used will be apparent after the work is finished, showing that the tools have been well selected, kept in good working order, and correctly applied. Tools used in work at the bench may be kept in racks at the back of the bench top, the most convenient location for those in frequent service, or they may be kept in drawers at the workman's right hand (Figs. 7, 8), especially if they are not often needed. Each should be provided with a definite place, so that it may be easily found when the occasion demanding its use arises. Cutting tools, as gravers, chisels,

scrapers, etc., ought to be kept sharp, and a good Arkansas stone, 6 inches long and 2 inches wide, should be provided to keep them in condition. This should be used with oil, and the blade of the tool not constantly sharpened in the same direction in order to avoid wearing grooves in the stone. It must be kept clean of the black mixture of finely divided steel and oil to ensure its best sharpening qualities. The workman must know how to put an edge on his tools.

The following are the principle bench tools in use for metal work:

Plate shears, straight and curved.

Pliers (flat-nose), in at least three sizes—one pair large and strong enough to be used in drawing wire.

Pliers (round-nose), two sizes.

Pliers, one pair with one beak rounded and the other flat—very useful in fitting clasps.

Side-cutting nippers for removing that portion of the platinum pins which projects beyond the backing.

Punching forceps, for punching holes in gold backings, for the platinum pins.

Clasp-bending forceps.

Plate nippers are employed for removing redundant portions of a plate, which they do more rapidly than could be accomplished with files.

Plate burnishers, straight and curved.

Horn mallet.

Riveting hammer.

Draw plate for reducing the size of wire.

Screw plate and taps, useful in the construction of regulating fixtures.

Plate gauge, standard American.

Solder tweezers and tongs.

Jewellers' saw frame and saws.

Small steel cold chisels for cutting out chamber.

Small hammer, weighing about 2 ounces.

Round-edged brass chaser for use in forming vacuum chambers and for carrying the plate into deep places.

Hand vise and pin vise.

A small variety of sizes of gravers, chisel and gouge forms. Those made for wood engravers are well tempered and answer admirably for dental laboratory uses. The graver will reach places during the finishing of dentures which would be inaccessible to the corundum wheel. They are also useful in correcting slight imperfections in zinc dies.

Files, half round, 5 or 6 inches long, moderately fine cut; round files, small variety, ranging from 6 to 12 inches in length, coarse and fine; flat files with safe edge, moderately coarse and fine. Files should be kept in a suitable rack, and not in a drawer with pliers, shears, etc., as contact with these and with each other will be sure to damage them.

Triangular steel scraper for removing file-marks on edges of plate and backings.

Small anvil set in lead.

Scissors, straight and curved, for cutting patterns for plates, etc.

Several points, made from broken excavators or worn-out pluggers,

used for marking upon gold or silver plates, picking wax or cement from invested cases, and numerous other purposes.

Blue pencil for marking plan of plate and clasps upon plaster casts.

The additional tools, appliances, and materials used in crown and bridge-work will be described in Chapter XVIII.

For vulcanite work the following are needed and will be discussed more in detail in the chapter on that subject:

Vulcanizer.

Vulcanite flasks and wrenches.

Flask press.

Vulcanite scrapers.

Files, half round and "rat tail."

Chisels.

Calipers for measuring thickness of plate.

Articulators.

Gas fitter's pliers for occasional use in tightening the bolts of vulcanite flasks and other rough work which would damage the ordinary bench pliers are convenient articles to have, and a small wood saw for reducing size of hard plaster casts is likewise useful.

The use of bench tools should be strictly confined to the purpose for which they were designed. They should be carefully kept from contact with plaster of Paris, the fumes of acids, and particularly from chlorine as evolved from nitro-hydrochloric acid in the quartation process of refining gold, which readily acts upon the surface of steel and iron.

CHAPTER II.

METALS AND ALLOYS USED IN PROSTHETIC DENTISTRY.

By Joseph Dupuy Hodgen, D.D.S.

Seventy-eight elements are at present known to us, of which the following is a complete list, arranged alphabetically, with their symbols and their atomic weights:

Table of Elements with International Atomic Weights, 1903.

		O = 16.*	H = 1.*			O = 16.*	H = 1.*
Aluminum	Al	27.1	26.9	Neodymium	Nd	143.6	142.5
Antimony	Sb	120.2	119.3	Neon	Ne	20.0	19.9
Argon	A	39.9	39.6	Nickel	Ni	58.7	58.3
Arsenicum	As	75.0	74.4	Nitrogen	N	14.04	13.93
Barium	Ba	137.4	136.4	Osmium	Os	191.0	189.6
Bismuth	Bi	208.5	206.9	Oxygen	O	16.0	15.88
Boron	B	11.0	10.9	Palladium	Pd	106.5	105.7
Bromine	Br	79.96	79.36	Phosphorus	P	31.0	30.77
Cadmium	Cd	112.4	111.6	Platinum	Pt	194.8	193.3
Caesium	Cs	133.0	132.0	Potassium	K	39.15	38.86
Calcium	Ca	40.1	39.8	Praseodymium	Pr	140.5	139.4
Carbon	C	12.0	11.91	Radium	Rd	225.0	223.3
Cerium	Ce	140.0	139.0	Rhodium	Rh	103.0	102.2
Chlorine	Cl	35.45	35.18	Rubidium	Rb	85.4	84.8
Chromium	Cr	52.1	51.7	Ruthenium	Ru	101.7	100.9
Cobalt	Co	59.0	58.56	Samarium	Sm	150.0	148.9
Columbium	Cb	94.0	93.3	Scandium	Sc	44.1	43.8
Copper	Cu	63.6	63.1	Selenium	Se	79.2	78.6
Erbium	Er	166.0	164.8	Silicon	Si	28.4	28.2
Fluorine	F	19.0	18.9	Silver	Ag	107.93	107.12
Gadolinium	Gd	156.0	155.0	Sodium	Na	23.05	22.88
Gallium	Ga	70.0	69.5	Strontium	Sr	87.6	86.94
Germanium	Ge	72.5	71.9	Sulphur	S	32.06	31.83
Glucinum	Gl	9.1	9.03	Tantalum	Ta	183.0	181.6
Gold	Au	197.2	195.7	Tellurium	Te	127.6	126.6
Helium	He	4.0	4.0	Terbium	Tb	160.0	158.8
Hydrogen	H	1.008	1.0	Thallium	Tl	204.1	202.6
Indium	In	114.0	113.1	Thorium	Th	232.5	230.8
Iodine	I	126.85	125.90	Thulium	Tm	171.0	169.7
Iridium	Ir	193.0	191.5	Tin	Sn	119.0	118.1
Iron	Fe	55.9	55.5	Titanium	Ti	48.1	47.7
Krypton	Kr	81.8	81.2	Tungsten	W	184.0	182.6
Lanthanum	La	138.9	137.9	Uranium	U	238.5	236.7
Lead	Pb	206.9	205.35	Vanadium	V	51.2	50.8
Lithium	Li	7.03	6.98	Xenon	Xe	128.0	127.0
Magnesium	Mg	24.36	24.18	Ytterbium	Yb	173.0	171.7
Manganese	Mn	55.0	54.6	Yttrium	Yt	89.0	88.3
Mercury	Hg	200.0	198.5	Zinc	Zn	65.4	64.9
Molybdenum	Mo	96.0	95.3	Zirconium	Zr	90.6	89.9

These seventy-eight elements are classed under two great divisions, viz., metallic and non-metallic.

* It will be understood that these atomic weights are *relative;* thus we have a list, in the first column of which oxygen is assigned the value of 16,—*i.e.*, without fraction for greater convenience in calculation. In this column hydrogen has a relative value of 1.008. The second column is a list of the atomic weights with hydrogen taken as the standard, when relatively oxygen becomes equal to 15.88

THE METALS.

Of the sixty-two elementary substances known as metals only fourteen are ordinarily employed in their true metallic condition. These are:

Iron,	Aluminum,	Gold,
Copper,	Nickel,	Silver.
Lead,	Antimony,	Mercury,
Zinc,	Magnesium,	Platinum.
Tin,	Bismuth,	

About twelve are more or less useful in the preparation of medicines, in the arts for coloring pigments, and for alloying purposes. These are:

Potassium,	Barium,	Cobalt,
Sodium,	Manganesium,	Cadmium,
Calcium,	Arsenicum,	Titanium,
Lithium,	Chromium,	Uranium.

The remaining thirty-six are more or less rare, and as yet of little or no practical value in the metallic state.

The metallurgist groups the metals into two classes, which are known as noble and base:

Noble Metals.—Noble metals are those whose compounds with oxygen are decomposable by heat alone, at a temperature not exceeding redness. These are:

Mercury,	Platinum,	Ruthenium,
Silver,	Palladium,	Osmium,
Gold,	Rhodium,	Iridium.

Base Metals.—Base metals are those whose compounds with oxygen are not decomposable by heat alone, retaining oxygen at high temperatures.

The base metals are further subdivided with reference to their affinity for oxygen and other chemical properties.

First division. This contains five metals. They are very readily oxidized, and their oxides are all soluble in water, giving it a strongly alkaline reaction; so also are their phosphates and carbonates, with the exception of lithium phosphate, which is quite insoluble, and the carbonate, which is only sparingly soluble. They all energetically decompose water at ordinary temperatures, liberating hydrogen and forming hydrates in solution. They are soft, of low specific gravity, and fusible at low temperatures. These are:

Potassium,	Lithium,	Cæsium
Sodium,	Rubidium,	

Second division. This contains four metals, all of which, with the exception of magnesium, decompose water at ordinary temperatures, combining with the oxygen. Their oxides are more or less soluble in water, rendering it alkaline; but their neutral carbonates and phosphates are insoluble. These are:

Barium,	Strontium,	Calcium,
	Magnesium.	

Third division. This contains thirteen metals, of which but three are of much importance. Those which have been isolated do not decompose water at ordinary temperatures without the addition of a weak acid or a slight rise of temperature. Their oxides and carbonates are insoluble in water. These are:

Aluminum,	Thorium,	Cerium,
Chromium,	Yttrium,	Lanthanum,
Titanium,	Zirconium,	Didymium,
Glucinum,	Erbium,	Tantalum,
	Columbium	

Fourth division. This contains nine metals, the chief of which decompose water at a red heat. These are:

Iron,	Manganesium,	Vanadium,
Nickel,	Zinc,	Thallium,
Cobalt,	Uranium,	Indium.

Fifth division. This contains four metals, which do not decompose water at any temperature. These are:

Cadmium,	Lead,	Bismuth,
	Copper.	

Sixth division. This contains six metals. All the higher oxides of these metals have acid properties. These are:

Tin,	Arsenicum,	Tungsten,
Antimony,	Molybdenum,	Tellurium.

PROPERTIES OF THE METALS.

A metal is an elementary substance, solid at ordinary temperatures, with the single exception of mercury (a liquid solidifying at —39° C.), having a peculiar lustre, called "metallic lustre," and the property of replacing hydrogen in chemical reactions, as, for example,

$$Zn + H_2SO_4 = ZnSO_4 + H_2,$$

insoluble in water, a good conductor of heat and electricity, and possessing the quality of uniting with oxygen to form a basic oxide.

No line can be sharply drawn between metals and non-metals; just as none can be drawn between soluble and insoluble, poisonous and non-poisonous substances, yet, from a general point of view, this class of elements admits of the foregoing definition.

The metals possess a number of characteristic properties, which may be noted as follows:

Non-transparency.—Metals, as a rule, are non-transparent, or opaque, yet some have proven to possess the property of transparency in a low degree at least. In the case of gold, through the leaf, or thin films produced chemically on glass plate, a light-green color is transmitted. Also very thin films of mercury are said to transmit light with a violet-

blue color, and copper, it is claimed, is somewhat translucent; while silver in infinitely thin films is absolutely opaque.

Color.—The color of most metals is white, and ranges from the pure white of silver and tin to the bluish hue of lead. Bismuth is a light gray, with a delicate tinge of red. Copper is called the "red metal." Gold is a rich yellow, barium and strontium a straw color, while calcium exhibits a little deeper shade of that color.

Luster.—Polished metallic surfaces, like those of other solids, divide any incident ray into two parts, of which one is refracted, while the other is reflected, with this difference, however, that the former is completely absorbed, while the latter is reflected, which latter accounts in all likelihood for the metallic luster.

Odor and Taste.—Most metals are destitute of odor and taste. Peculiar odors are, however, evolved from some of them when heated; in fact, one of the means of discriminating arsenicum consists in the recognition of its characteristic smell of garlic when heated. Iron, copper or zinc when heated also evolve peculiar odors. The taste which is perceived in some is no doubt due to their peculiar character, although in some cases it may depend upon voltaic action set up by the chemical agency of the saliva, the metal not being perfectly pure. If a piece of zinc be placed upon the tongue, and a piece of silver under it, and the edges joined, a metallic taste will be perceived dependent on slow solution of the zinc under electric action. The odor, Dr. Essig says,[1] "may be noticed in a marked degree when holding in the hand a mass of an alloy composed of gold, platinum, tin, and silver prepared for use as amalgam. The moisture of the hand, aided by its heightened temperature, seems to promote the electric action."

Crystalline Form.—Most metals are capable of crystallization, and their crystals belong to the following systems: Regular—silver, gold, palladium, mercury, copper, iron, lead; quadratic—tin, potassium; rhombic—antimony, bismuth, tellurium, zinc, magnesium.

Perhaps all metals in solidifying assume a crystalline structure, which differs only in degree of visibility. Antimony, bismuth, and zinc exhibit a very distinct crystalline structure plainly visible in broken ingots. Tin is also crystalline, which fact is evinced by the "tin cry" when a bar of the metal is bent, the crystal faces sliding over one another; but the bar is not easily broken, and exhibits an apparently non-crystalline fracture. Gold, silver, copper, aluminum, cadmium, iron, lead, cobalt, and nickel are practically amorphous, the crystals being so closely packed as to virtually produce a homogeneous mass.

Malleability, Ductility, and Tenacity.—These are properties possessed by some metals by reason of the cohesive power of their molecules, and are to that extent kindred.

Malleability.—Malleability is that quality possessed by a metal which permits it to be hammered or rolled into thin sheets without breach of continuity. While many metals possess this property to some degree, it is most wonderfully exemplified in gold. Leaves of this

[1] Dental Metallurgy, p. 20.

metal have been produced $\frac{1}{370000}$ of an inch in thickness, each grain of which will cover an area of 75 square inches.

Ductility.—Ductility is that property possessed by some metals by virtue of which they may be drawn into wire. The operation consists in forcibly drawing the metal through a series of holes, in a hard-steel draw-plate, which gradually decrease in size. Gold is also the most ductile of all metals, a single grain of it having been drawn into a wire 550 feet in length. This was accomplished by covering the gold wire with silver, which is also remarkably ductile, thus making a composite wire of greater thickness. After drawing this down to the greatest possible degree of tenuity, the silver was dissolved off by nitric acid, leaving a gold wire $\frac{1}{5000}$ of an inch in diameter.

Tenacity.—Tenacity is that property possessed by metals, in consequence of which they resist rupture when exposed to tension. Their relative tenacity may be ascertained by preparing wires of exactly equal diameters and comparing the number of pounds weight each will sustain before rupture.

These properties are shown relatively for some of the more important metals in the following table:

Malleability.	Ductility.	Tenacity.
1. Gold.	1. Gold.	1. Iron.
2. Silver.	2. Silver.	2. Copper.
3. Copper.	3. Platinum.	3. Platinum.
4. Tin.	4. Iron.	4. Silver.
5. Cadmium.	5. Nickel.	5. Gold.
6. Platinum.	6. Copper.	6. Zinc.
7. Lead.	7. Palladium.	7. Tin.
8. Zinc.	8. Aluminum.	8. Lead.
9. Iron.	9. Cadmium.	
10. Nickel.	10. Zinc.	
11. Palladium.	11. Tin.	
	12. Lead.	

The two properties of malleability and ductility are closely related to each other, yet, as may be seen from the above table, they do not always parallel each other, for the reason that ductility in a higher degree than malleability is determined by the tenacity of the metal; for example, tin, though quite malleable, is very slightly ductile, and iron, while ninth in point of malleability, is fourth in ductility. In the operation of hammering out a metal which the quality of malleability permits the granular particles are flattened and spread in all directions, while in those allowed by its ductility each granular particle is elongated into a fibre.

There are several conditions which materially modify the properties of malleability, ductility, and tenacity, one of the most important of which is the state of purity of the metal. Gold is the most malleable of all metals, yet if the merest trace of lead, itself a soft and malleable metal, be contained in it, the gold becomes too brittle to be worked, and especially is this the case if the gold contains any silver, as is frequently the case. This destruction of malleability and tenacity is yet more

pronounced when antimony or similar metals are mixed with gold, even in minute quantities.[1]

Temperature also exercises a very great modifying influence over these properties; for example, a bar of zinc obtained by casting is exceedingly brittle, but when heated to 100° or 150° C. it may be rolled into thin sheets or drawn into wire. Such sheet or wire then remains malleable and ductile after cooling. The explanation of this remarkable fact is, that the loosely cohering crystals have become intertwisted and forced into absolute contact with each other, and this is supported by the fact that the rolled zinc has a somewhat higher specific gravity than the original ingot. If the temperature be carried to 205° C. the metal again becomes so brittle that it may be powdered in a mortar. Extreme care, therefore, must be exercised in the handling of hot zinc dies, for if by accident one be dropped upon a hard surface it is likely to be spoiled. Aluminum, magnesium, and some other metals, which at ordinary temperatures possess little or no ductility, may be drawn into wire when heated.

These qualities are greatly diminished in alloys by heating. Some forms of brass, for example, which are soft, tenacious, and ductile at ordinary temperatures, are made quite brittle by heating to dull redness. Again, it is quite certain that 18-carat gold solder is brittle at red heat.

The tenacity of metals in general is greatly diminished by heating. The exceptions to this are in the cases of iron, steel, and gold.

The following table shows the results obtained by Wertheim[2] in his experiments on a number of the metals at temperatures from 15° to 20° C.:

Name.	Permanent wire one square mm. section, weight in (in kilos) causing	
	Permanent elongation of 1/20000	Breakage.
Iron, drawn	32.0	61.0
" annealed	Under 5.0	47.0
Copper, drawn	12.0	40.0
" annealed	Under 3.0	30.0
Platinum, drawn	....	34.0
" annealed	....	23.0
Silver, drawn	11.3	29.0
" annealed	2.6	16.0
Gold, drawn	13.5	27.0
" annealed	3.0	10.0
Zinc, drawn	0.75	13.0
" annealed	1.0	
Tin, drawn	0.45	2.45
" annealed	0.2	
Lead, drawn	0.25	2.1
" annealed	0 2	1.8

Annealing.—Pure iron, copper, silver, and other metals are easily drawn into wire, rolled into sheets, or flattened under the hammer. But

[1] See Gold.

[2] Annales de Chimie et de Physique (III.), vol. xii.

all these operations render the metals harder, and reduce from their pliability. Their original softness can be restored to them by annealing —*i. e.*, by heating them more or less and then plunging them into cool water, oil, etc. In the case of iron, however, this applies only if the metal is perfectly pure. If it contains a few parts carbon per thousand, the annealing process, instead of softening the metal, gives it a "temper," meaning a higher degree of hardness and elasticity.[1]

Welding.—The process of joining two clean surfaces of a metal together by pressure is called welding. This property is possessed by iron at white heat, but lead and gold will cohere at ordinary temperatures in proportion to their purity. Two pieces of iron may be welded by a current of electricity sent through their junction, when the metal is heated by the resistance offered to the passage of the current.

Forging.—The process of hammering metals out into various shapes is called forging. With some it may be done when they are cold, while in others they must be hot. It illustrates the solid flow of metals.

Elasticity.—All metals are elastic to this extent, that a change in their form brought about by a stress not exceeding certain limit values, will disappear when the stress is removed. Strains exceeding the "limit of elasticity" result in permanent deformation, or, if sufficiently great, in rupture. This property may be increased in some metals by compounding and alloying. Thus, iron compounded with the proper amount of carbon, has its elasticity increased to the very highest degree, while the metal itself is almost devoid of the quality. The same is true of copper and zinc in some forms of brass, also of gold and platinum when alloyed with copper; both the latter are soft and have little elasticity, yet when combined in proper proportions with copper an alloy is produced which is quite elastic, and may be used for clasps for artificial dentures.

Sonorousness.—This is a property possessed by the harder metals, and is quite marked in certain alloys, such as those of copper and tin known as bell-metal. Lead, which is but feebly, if at all, sonorous, may become so, it is claimed, if cast in the shape of a mushroom. Aluminum emits a characteristic sound when struck. The first article known to have been made of aluminum was a baby rattle for the infant prince imperial of France, for which purpose it was well fitted on account of its sonorousness. Impurities sometimes increase the sonorousness of a metal, as in the case of antimony in lead.

Fusibility and Volatility.—All metals may be fused, and most of them are capable of being volatilized, but the temperature at which they become fluid differs greatly in different metals, as the following table shows:

Name of metal.	Fusing point. Centigrade.	Fusing point. Fahrenheit.	Authority.
Mercury	—39.0	—38.2	
Cæsium	+ 26 to 27.0	+78.8	Setterberg.
Gallium	30.0	86.0	L. de Boisbaudran.
Rubidium	38.5	101.3	Bunsen.
Potassium	62.5	144.5	Bunsen.

[1] See Iron.

Names of metal.	Fusing point. Centigrade.	Fusing point. Fahrenheit.	Authority.
Sodium	95.5	203.9	Bunsen.
Indium	176.0	348.8	Richter (?).
Lithium	180.0	356.0	(?)
Tin	228.0	442.4	Rudberg.
Bismuth	264.0	507.2	Rudberg.
Thalium	290.0	554.0	Lamy.
Cadmium	320.0	608.0	Rudberg.
Lead	325.0	617.0	
Zinc	415.0	779.0	Person.
Antimony	425.0	797.0	
Incipient red heat	525.0	977.0	Pouillet.
Aluminum	625.0	1157.0	
Magnesium	750.0	1382.0	
Cherry-red heat	700.0	1292.0	Pouillet.
Silver	1040.0	1904.0	Becquerel.
Gold	1100.0	2012.0	
Yellow heat	1100 0	2012.0	Pouillet.
Copper	1200.0	2192.0	
Iron, wrought	1300 to 1400.0	2372 to 2552.0	
Iron, chemically pure	higher–1600 0	2912 0	
Cobalt	1400.0	2552 0	
Nickel	1600 0	2912.0	
Uranium	(?)	(?)	
Dazzling white heat	1500 to 1600.0	2732 to 2912.0	Pouillet.
Palladium	1600.0	2912.0	
Oxyhydrogen flame	....	....	
Platinum	2000.0	3632.0	
Iridium	....	....	
Rhodium	....	....	
Ruthenium	....	....	
Maximum temperature of oxyhydrogen flame	2870.0	5198.0	Bunsen.[1]

Osmium does not melt at 2870°—*i.e.*, is as yet infusible.

Metals may be characterized as fixed and volatile. Of their volatility we have little precise knowledge. The boiling points of a few are given in the following table:

Name of metal.	Boiling point.	Authority.
Mercury	357.3° C.	Regnault.
Cadmium	860.0° "	Deville and Troost
Zinc	1040.0° "	Deville and Troost
Potassium	Below 1040.0° "	Dewar and Dittmar.
Sodium	Above 1040.0° "	

For practical purposes the volatility of metals may be classed as follows:

1. Distillable below redness: Mercury.
2. Those distillable at red heats.

Cadmium,	Magnesium,	Sodium.
Zinc,	Potassium,	

[1] Jahresb. f. Chem., 1867, p. 41; Phil. Mag., xxxiv. 489.

3. Those which are volatilized more or less readily when heated beyond their fusing points in open crucibles :

Antimony (very readily),	Bismuth,	Silver.
Lead,	Tin,	

4. Those which are with very great difficulty volatilized, if at all :

Gold,	Copper (?).

5. Those which are practically "fixed," or non-volatile :

Copper (?),	Cobalt,	Lithium,
Iron,	Calcium,	Strontium,
Nickel,	Aluminum,	Barium.

"In the oxyhydrogen flame silver boils, forming a blue vapor, while platinum volatilizes slowly, and osmium, though infusible, very readily."[1]

"It is doubtful," says Makins, "if it (gold) is volatile *per se.* But if gold be alloyed with copper, it has been shown by Napier to be considerably volatilized, so that quantities, amounting to $4\frac{1}{2}$ grains, could be collected during the pouring out of 30 pounds' weight from a crucible. . . . That mixtures of gold, silver, and lead, when cupelled together, volatilize considerably."

Specific Heat.—Equal weights of different metals have been found to absorb different amounts of heat when subjected to the same temperature. They, indeed, possess different capacities for heat. Thus, the amount of heat necessary to raise a given weight of water has been found to be 31 times as great as that required to raise an equal weight of platinum through the same range of temperature; or, in other words, the amount of heat required to raise a given weight of water through 100° C. will raise 31 times the same weight of platinum through 100° C. of temperature. Thus, water being taken as the standard or unit, the specific heat of platinum is $\frac{1}{31}$, or 0.032 that of water.

TABLE OF SPECIFIC HEATS.

1. Iron	0.1138
2. Nickel	0.1086
3. Cobalt	0.1070
4. Zinc	0.0956
5. Copper	0.0952
6. Palladium	0.0593
7. Silver	0.0570
8. Cadmium	0.0567
9. Tin	0.0562
10. Antimony	0.0508
11. Mercury	0.0333
12. Gold	0.0324
13. Platinum	0.0322
14. Lead	0.0314
15. Bismuth	0.0308

[1] William Dittmar.

Expansibility.—The expansion of metals by heat varies greatly. The coefficient of expansion is constant only in metals that crystallize in the regular system. The others expand differently in the direction of the different axes of their crystals, and to eliminate this source of uncertainty in making estimates of their expansibility, they are employed as compressed powders.

The following table gives the linear expansion from 0° to 100° C., according to Fizeau, the length at 0° being taken as unity.[1]

Name of metal.	Expansion. 0° to 100° C.
Platinum, cast	0.000907
Gold, cast	0.001451
Silver, cast	0.001936
Copper, native	0.001708
Copper, artificial	0.001869
Iron, soft	0.001228
Steel, cast	0.001110
Bismuth, mean expansion	0.001374
Tin, compressed powder	0.002269
Lead, cast	0.002948
Zinc	0.002905
Cadmium, compressed powder	0.003102
Aluminum, cast	0.002336
Mercury	0.018153

"The high rate of expansibility of zinc renders it particularly valuable as a metal for dies upon which to form plates for the mouth in many cases. The metal is cast while fluid and at its extreme limit of expansion, which upon cooling returns to its minimum dimensions, and thus furnishes a cast a little smaller than the plaster model which it represents. It has been found that this contraction of the zinc die a trifle more than compensates for the expansion which takes place in the plaster model in setting, and in the majority of cases a plate made thereon adapts itself more accurately to the mouth than one made upon a die of less expansible metal. Even if the contraction undergone by the zinc is so great as to produce a die somewhat smaller than the mouth, so far from being a detriment, it is a positive advantage in most cases of full upper replacement, as under such conditions the pressure of the finished plate is greater upon the alveolar ridge than upon the central portions of the hard palate—a state of affairs the advantages of which are sufficiently obvious without explanation."[2]

Conductivity.—Metals are good conductors of heat and electricity, but these qualities are very differently exhibited in different metals. An exact knowledge of these conductivities is of great scientific and practical importance to the dentist, and too much attention cannot be given their consideration.

The following table gives the thermic and electric conductivities of some of the more important metals and alloys:

[1] William Dittmar.

[2] Dr. E. C. Kirk, Am. System of Dentistry, vol. iii. p. 793.

Name of metal.	Relative conductivity.	
	Thermic.	Electric, at 0° C.
Silver	100.0	100.00
Copper	73.6	99.95
Gold	53.2	77.96
Tin	14.5	12.36
Iron	11.9	16.81
Lead	8.5	8.32
Platinum	8.4	18.80
Bismuth	1.8	1.24
Brass	23.6	
Steel	11.6	
German silver	7.3	7.67
Rose fusible metal	2.8	
Pianoforte Wire	....	14.40

Makins states that among the results of Dr. Matthiessen's experiments upon the electric conductivity of metals "are the facts that impurity of a metal or alloying it greatly diminishes its conducting power. Rise of temperature again has the same effect. Thus between 32° F. and 212° (or 0° C. and 100°) great diminution takes place, and that not uniformly, as some lose it much more in proportion than others, by thus raising the temperature. Many lose as much as 25 per cent. of their conducting power."

An illustration of the comparative conductivity of the metals is observed in the electric furnaces with platinum coils. The electricity is readily transmitted from its source by the copper efferent wire, but when it meets the platinum that metal offers so much resistance to the passage of the current, on account of its low conducting power, that it becomes white-heated—incandescent.

Specific Gravity.—This property varies in different metals from 0.594 (lithium) to 22.48 (osmium), as the following table shows:

Name of metal.	Specific gravity.	Authority.
Lithium	0.594	Bunsen.
Potassium	0.875	Baumhauer.
Sodium	0.9735	Baumhauer.
Rubidium	1.52	Bunsen.
Calcium	1.578	Bunsen and Matthiessen.
Magnesium	1.743	Bunsen.
Cæsium	1.88	Setterberg.
Glucinum	2.1	Debray.
Strontium	2.5	
Aluminum	2.583	Mallet.
Barium	Over 4.0	Clarke.
Zirconium	4.15	Troost.
Vanadium	5.5	Roscoe.
Gallium	5.9	Lecoq de Boisbaudran.
Lanthanum	6.163	Lecoq de Boisbaudran.
Didymium	6.544	Hillebrandt and Norton.
Antimony	6.715	Marchand and Scheerer.
Cerium	6.728	Hillebrandt and Norton.
Chromium	6.81	Wöhler.

Name of metal.	Specific gravity.	Authority.
Zinc	6.915	Karsten.
Manganesium . .	7.14	Brunner.
Tin	7.29 .	
Indium . . .	7.42	Richter.
Iron	7.844	Berzelius.
Nickel	8.279	Richter.
Cadmium . . .	8.546	Schröder.
Cobalt	8.5	
Molybdenum . .	8.6	Debray.
Copper . . .	8.94	
Bismuth . . .	9.823	Holzmann.
Silver	10.4	Holzmann.
Lead	11.25	Deville.
Palladium . . .	11.4	Deville and Debray.
Thallium . . .	11.86	Crookes.
Rhodium . . .	12.1	Bunsen.
Ruthenium . . .	12.26	Deville and Debray
Mercury . . .	13.595	H. Kopp.
Tungsten . . .	16.54	Wöhler.
Uranium . . .	18.33	Péligot.
Gold	19.265	Matthiessen.
Platinum . . .	21.46	
Iridium . . .	22.4	
Osmium . . .	22.477	Deville and Debray

COMPOUNDS OF METALS AND NON-METALS.

Metals mix with each other indefinitely to form alloys, preserving the metallic appearance and properties. They combine with non-metals in definite chemical proportions to form compounds of a more precise nature, in which case the metallic characters are almost invariably lost. These definite compounds include the

Oxides	Bromides,	Selenides,
Sulphides,	Fluorides,	Tellurides
Chlorides,	Cyanides,	

They also combine with

Nitrogen,	Boron,	Carbon.
Phosphorus,	Silicon,	

ALLOYS.

An alloy is the compound or mixture of two or more metals effected by fusion.

An amalgam is an alloy of two or more metals, one of which is mercury.

Few metals are employed in the pure state, with the exception of iron, copper, lead, tin, zinc, platinum, and aluminum; they are more frequently used for technical purposes in the form of alloys. Every

industrial application requires special qualities that may not exist in any single metal, but which may be produced by the proper mixture of two or more. For example, silver and gold are much too soft and pliable for plate, coin, or jewelry, but by the addition of certain amounts of copper they are rendered harder and more elastic, while their color and other valuable qualities are not impaired. Copper is also too soft and tough to be wrought in a lathe, but when alloyed with zinc it forms a hard, beautiful, yellow-colored alloy known as brass, of great usefulness and more easily worked than the pure metal.

Alloys are extremely interesting, from a scientific standpoint, for they may be regarded not only as mere mixtures of metals, but in many instances as true chemical compounds. Matthiessen[1] regarded it as probable that the condition of an alloy of two metals in a melted state may be either that of (1) a solution of one metal in another; (2) a chemical combination; (3) a mechanical mixture or; (4) a solution or mixture of two or all of the above; and that similar differences may exist as to its condition in the solid state, defining a solid solution as "a perfectly homogeneous diffusion of one body in another."

The Physical Properties of Alloys.—The physical properties of an alloy cannot be anticipated from those of its constituent metals, and are only determinable by actual experiment. Very minute proportions of some metals added to others will produce an alloy with properties foreign to either of the constituents. Thus, a small quantity of lead fused with gold will produce a brittle alloy, though each metal is malleable.

Specific Gravity.—If this property be calculated as the mean of that of the component metals of the alloy, the result may be greater than, equal to, or less than the actual specific gravity of the alloy determined by experiment. Thus, the alloys of silver and gold have a less specific gravity than the theoretical mean of the components; whereas copper and zinc vary in the opposite direction.

The following table,[2] by Thénard, shows examples of this variation:

Alloys possessing a greater specific gravity than the mean of their components.			Alloys having a lower specific gravity than the mean of their components.		
Gold	and	Zinc.	Gold	and	Silver.
"	"	Tin.	"	"	Iron.
"	"	Bismuth.	"	"	Lead
"	"	Antimony.	"	"	Copper.
"	"	Cobalt.	"	"	Iridium
Silver	"	Zinc.	"	"	Nickel.
"	"	Lead.	Silver	"	Copper
"	"	Tin.	Copper	"	Lead.
"	"	Bismuth.	Iron	"	Bismuth.
"	"	Antimony.	"	"	Antimony.
Copper	"	Zinc.	"	"	Lead.
"	"	Tin.	Tin	"	Lead.
"	"	Palladium.	"	"	Palladium.
"	"	Bismuth.	"	"	Antimony.
"	"	Antimony.	Nickel	"	Arsenic.
Lead	"	Bismuth	Zinc	"	Antimony.
"	"	Antimony.			
Platinum	"	Molybdenum.			
Palladium	"	Bismuth.			

[1] British Association Reports, 1863, p. 97.

[2] Phillips' Metallurgy.

It is common among authorities who publish determinations upon specific gravities of the alloys to give the calculated as well as the observed specific gravity.

The Color.—The color of an alloy usually resembles that of the metal which predominates. Some few exceptions are quite notable; for instance, gold 2 to 6, and silver 1 part produces an alloy of a greenish color, and it is said that $\frac{1}{24}$ part of silver is sufficient to modify the color of gold. Nickel and copper form alloys varying from copper-red to the bluish-white of nickel. With a content of 30 per cent. of nickel the alloy is silver white; while with zinc, copper yields a variety of shades, from the silver white of brass consisting of copper 43, and zinc 57 parts, to that of red brass, which contains 80 per cent. or more of copper.

Malleability, Ductility, and Tenacity.—These properties are generally very much modified by alloying. As a rule the malleability and ductility are decreased, even when two malleable and ductile metals, such as gold and lead, are alloyed together—a very small content of lead destroying the malleability and ductility of the noble metal. Again, copper 94 and tin 6 parts form an exceedingly brittle alloy. Generally the ductility decreases, while the hardness as compared with that of the constituent metals increases to a considerable extent; for example, gold and platinum, two very ductile and soft metals, afford an alloy much harder and of greater elasticity than either. Gold and silver, being too soft for currency, are alloyed with 10 per cent. of copper, which gives them the required hardness. A few metals, antimony, for instance, possess the property of making metals harder. Mr. Makins states that $\frac{1}{1900}$ part of this brittle metal will make gold quite unworkable. As a rule, a brittle and a ductile metal afford a brittle alloy; yet copper and zinc yield a malleable and ductile alloy in brass.

The tenacity is generally very much increased, as is shown by the following results of Matthiessen's experiments. Wires of the same gauge were employed, and the weights causing their rupture before and after alloying noted as follows:

	Pounds at rupture.
Copper, unalloyed	25 to 30
Tin, "	under 7
Lead, "	" 7
Gold, "	20 to 25
Silver, "	45 " 50
Platinum, "	45 " 50
Iron, "	80 " 90

	Pounds at rupture.
Copper, alloyed with 12 per cent. Tin	80 to 90
Tin, " " " " Copper	7
Lead, " " Tin	7
Gold, " " Copper	70
Silver, " " Platinum	75 to 80
Steel (iron compounded with carbon)	above 200

Fusibility.—The fusing point of an alloy is always lower than that of the least fusible metal entering into its composition, and is sometimes lower than that of any of the components. Thus an alloy composed of 10 parts lead and 4 parts tin fuses at 470° F., melting lower than the less fusible lead (617° F.), but at a greater temperature than tin (442° F.); and an alloy composed of 4 parts lead, 2 parts tin, 5 to 8 parts bismuth, and 1 to 2 parts cadmium (Wood's metal) melts at 140° to 161° F., lower than that of any of its constituents—tin being the most fusible (442° F.). Alloys of lead and silver, containing a small quantity of the latter, are more fusible than lead, and sodium and potassium form an alloy fluid at ordinary temperatures.

Matthiessen[1] explains why the fusing point of alloys is uniformly lower than the mean of those of their constituents: "It is generally admitted that matter in the solid state exhibits excess of attraction over repulsion, while in the liquid state these forces are balanced, and in the gaseous state repulsion predominates over attraction. Let us assume that similar particles of matter attract each other more powerfully than dissimilar ones attract each other. It will then follow that the attraction subsisting between the particles of a mixture will be sooner overcome by repulsion than will the attraction in the case of a homogeneous body; hence, mixtures should fuse more readily than their constituents."

Sonorousness.—This property is most wonderfully developed in some instances by alloying. Copper and tin, two metals which possess the quality in but a small degree comparatively, unite to form an alloy known as "bell metal."

Conductivity.—The property of conductivity, either for electricity or heat, in an alloy is much inferior to that of the pure metals. Advantage is taken of the high electric resistance in some of the alloys, such as German silver, for measuring the resistance of long lines of telegraph wire, the electromotive force or working power of batteries, for making rheostats and other apparatus for controlling the electric current, etc.

Decomposition.—Heat decomposes alloys containing volatile metals like mercury or zinc. It requires a temperature much above the boiling point of the metal, however, to completely separate all traces of it from an alloy, and in most instances this cannot be accomplished even then without the assistance of chemical agency. When gold is contaminated with tin, the latter cannot be removed entirely by roasting; but if heated with small quantities of potassium nitrate, which serves to oxidize the base metal, it may be entirely removed. Mercury may be completely separated by roasting; it volatilizes at about 675° F. When endeavoring to expel it from old amalgam fillings, however, the mass should be heated bright red.

Annealing and Tempering.—Annealing is a process employed in the the working of various metals and alloys to reduce the observed brittleness and stiffness which result from the change of molecular struc-

[1] Makins' Metallurgy, p. 65.

ture, produced by hammering, long-continued vibration, rolling, or sudden cooling. Bell metal is brittle, and cracks under the hammer, cold as well as heated. If it be repeatedly brought to a dark-red heat and quickly cooled by immersion in water, its brittleness is so far decreased that it can be hammered and stamped.

The dentist, in swaging a flat sheet of gold alloy to conform to his dies, must stop at intervals and anneal the piece of metal to prevent its splitting under his blows and pressure.

It is said sudden changes of temperature have the effect, almost invariably, of rendering metals brittle. Gold, silver and platinum, should be heated for a re-arrangement of their molecular structure and allowed to cool slowly. Lead, tin, and zinc are annealed by immersion in water, which is then made to boil and cool slowly. Steel should not be annealed in an open fire, as the carbon which enters the iron as an element combines with the oxygen of the air to the detriment of the steel.

Oxidation.—Alloys are usually more easily oxidized than their constituents. Mr. Makins[1] says: "The superior oxidizability of one constituent of an alloy appears to be assisted by galvanic action set up. This is always the case where an electro-negative, or acid-forming metal, is alloyed with an electro-positive, or base-producing one. Chemical action is, therefore, generally more energetic on an alloy than upon a simple metal; and, indeed, metals which when unalloyed are unaffected by an acid, will be acted upon by the same acid when alloyed with another metal which is soluble in the acid employed. Thus platinum is quite insoluble in nitric acid, but if it be alloyed with a large proportion of silver, it will be dissolved with the silver by the nitric acid, and that to the extent of a tenth of the weight of silver."

Nearly all metals in a state of fusion have a tendency to dissolve a greater or less amount of their oxides; and this is particularly true of alloys, as then the metals are in a state of solution, a condition most favorable to chemical change. A striking illustration of this came under the author's notice in a dental-amalgam alloy prepared by Dr. S. E. Knowles, consisting of 2 parts tin and 1 part each of silver and aluminum. There was no exceptional difficulty in thoroughly blending the constituents, and the alloy resembled the ordinary dental-amalgam alloy when comminuted and ready for mercury, but upon the addition of mercury the oxidation of the whole was so rapid that a very considerable heat was evolved, and so complete that nothing remained but a black stain.

The best preventive against this formation of oxides and their subsequent absorption is to protect the molten alloy by a layer of pulverized charcoal or some of the fluxes. A reduction of much of the oxide formed may be effected by vigorous stirring with a stick of green wood. The careful addition of not more than $\frac{8}{1000}$ to $\frac{10}{1000}$ parts of phosphorus has been found an excellent agent for the deoxidation of the oxides dissolved in bronze.

[1] Makins' Metallurgy, p. 64.

Zinc and the alloys used in the dental laboratory for making dies, after repeated melting and casting in contact with the air, often become thick and pasty from dissolved oxides; and their valuable working qualities are so seriously impaired that they fail to copy the fine lines of the mold and produce a perfect die. Their properties may be restored to some extent by melting under pulverized charcoal or tallow, and vigorously stirring with a stick of green wood, or by dissolving in the molten metal a small quantity of aluminum.

Influence of Certain Metals in Alloys.—Certain metals when present in an alloy confer upon it definite properties which are in many instances characteristic; thus, in a general way, mercury, cadmium, and bismuth increase fusibility; tin, hardness and tenacity; antimony and arsenic, hardness and brittleness.

Solder.—A solder is an alloy or metal used for cementing or binding metallic surfaces or margins together, and the process is usually effected by heat. Ordinary solders may be hard or soft.

The Hard Solders comprise those which require a red heat for their melting.

The Soft Solders are those used by plumbers and tinsmiths, and consist principally of lead and tin, with sometimes an addition of bismuth.

Brazier's Solder, for uniting the surfaces of copper, brass, etc., is usually composed of copper and zinc, nearly equal parts, with a small addition of tin, and sometimes antimony.

Silver is the proper solder for German-silver articles, and gold or an alloy of gold and platinum for platinum.

In soldering, the surfaces or edges to be united must be kept free from oxidation and dirt. To keep them unoxidized during the operation several fluxes are used, such as dehydrated borax, or some of the reliable prepared compounds on the market for gold, silver, brass, or copper soldering; rosin, or a solution of zinc chloride, for tin plate; zinc chloride for zinc, and rosin and tallow for lead and tin.

Among the requirements of a good gold solder the most important are carat, color, strength, and fusing point. In fineness it should be equal, or nearly equal, to the plate, its color and strength as near as possible the same, while the fusing point should be a trifle lower—the nearer the melting point of the plate, the better the results.

To obtain these qualities it is necessary to prepare a solder by the addition of some metal which will fuse at a lower temperature than any of the various parts of the plate. Zinc is admirably suited for this purpose, and is generally used, since it permits of a solder as fine, or nearly as fine, as the plate. In addition to this it also possesses the advantage of yielding a more fluid solder than copper and silver, permitting it to flow very freely. On account of the oxidation or volatilization which takes place, it is observed that any subsequent fusing requires a greater heat. An advantage is also obtained in this fact, since it enables more perfect second solderings with the same alloy.

The process of soldering is a cementation by superficial alloying,

and is admirably illustrated in the operation of soldering platinum bases with pure gold for continuous-gum dentures. By means of the blowpipe the gold is flowed over the platinum surfaces thus joining them. If the joint is not well made, and an intervening space is filled with gold, this is not as strong as a close joint. This, however, is all remedied during the process of baking the body and enamel, as the high heat required for this so diminishes the cohesive power of the platinum that it readily and completely alloys with the gold, producing a stronger joint of a platinum-gold alloy, which is observed to be the same color as the platinum.

Autogenous Soldering is a process of soldering by direct fusion of the contiguous parts, without the intervention of a more fusible alloy. It is extensively used in uniting ends of bands for collar crowns.

Preparation of Alloys.—This would seem to be a simple task, but in order to produce an accurate result it is far from being as easy as it may seem. Most alloys are prepared by directly melting the metals together, but much skill, judgment, and experience are required to determine when it is best to add each constituent, and the amount of each to be used, to protect the molten mass, and to handle it generally.

The metal having the highest fusing point is generally melted first, and the others are added in the reverse order of their fusibility.

The varying densities of the metals to be combined frequently render the formation of a homogeneous mass very difficult. In some instances the heavier metal tends to sink to the bottom, carrying with it a small quantity of the other, while the lighter, floating above, retains a small quantity of the heavier. For instance, only a small proportion of zinc will unite with lead, or aluminum with bismuth; but, as a rule, metals mix perfectly in the fluid state. When, however, the fluid mixture is poured into the ingot mold, it rarely happens that the solidified mass is perfectly homogeneous. The reason of this is that the addition of one metal to another produces an alloy, the solidifying point of which is usually lower than it should be according to calculations based upon the proportionate amounts and fusing points of the constituents. One particular mixture has a lower fusing point than any other possible mixture of the metals employed, and this is termed the eutectic alloy of that series. Aside from those possibly true chemical combinations of metals, a fluid mixture of two metals may be expected to begin depositing its less fusible constituent first, and, as the temperature falls, more and more of this element will be separated, the other constituent concentrating in the fluid residue until this has acquired the eutectic composition, when it will solidify as a whole in the spaces left between the already solidified particles. The more slowly the material solidifies, the more marked will be the separation that occurs. To obtain as homogeneous an alloy as possible, the metals, while in a state of fusion, must not be allowed to remain quiescent, but an intimate mixture effected by vigorous stirring, sticks of dry, soft wood being used for the purpose. By stirring the fused mass with one of these sticks the wood is more or less carbonized according to the temperature of the mass, gases are evolved from the carbonizing wood, which, by ascend-

ing in the fused mass, contribute to its intimate mixture. The stirring should continue for some time and the alloy then cooled as rapidly as possible.

For preparing alloys in a small way a crucible is used, and the alloy is covered with a suitable flux to protect it from the action of atmospheric air. Four sources of loss must be guarded against: (1) loss by oxidation; (2) loss by volatilization; (3) loss by chemical combination with the flux; (4) loss by fracture or solution of the crucible.

The first may be prevented by the use of one of the various fluxes, or covering the surface with pulverized charcoal. The second loss usually occurs through an endeavor to alloy a metal of a high fusing point with one which fuses at a low temperature. Under such circumstances the one requiring a high temperature should be fused first and well covered with flux melted to extreme fluidity; the more fusible metal should then be added in as large a piece as convenient and quickly thrust beneath the molten surface. The third source of loss is principally caused by the use of borax as a flux for some base metals. It is well known that in much borax a portion of the boric acid is not perfectly saturated, and this is especially true of the prepared article; and if melted with some base metals the free acid is absorbed, which, with the sodium borate, forms double salts of a glassy nature. Hence, by fusing some metals and alloys under borax, a certain portion will be lost in chemical combination. The fourth cause is guarded against by careful selection of crucibles. If alloys of low fusing metals are to be made, the ordinary clay or Hessian crucible is all that is necessary, and, indeed, with proper care, noble metals may be alloyed in it without danger of loss; but it is liable to perforation by corrosive fluxes, allowing the molten alloy to escape. Therefore, for the preparation of expensive alloys from noble metals, the employment of tried graphite or graphite and clay crucibles often saves much trouble and expense.

In some instances, especially when metals are known to form chemical combinations, it may be best to melt the one of lowest fusing point first, and then dissolve the other components in it. Or, those of low fusing point may be melted in one crucible, while those more difficult of fusion are melted in another, then combined in the molten state.

"Many alloys," says Mr. Brannt,[1] "possess the property of changing their nature by repeated remelting, several alloys being formed in this case, which show considerable differences, physically as well as chemically. The melting points of the new alloys are generally higher than those of the original alloy, and their hardness and ductility are also changed to a considerable extent. This phenomenon is frequently connected with many evils for the further application of the alloys, and in preparing alloys showing this property the fusion of the metals and subsequent cooling of the fused mass should be effected as rapidly as possible."

Although most of the heavier metals are at present used in the preparation of alloys, copper, zinc, tin, lead, silver, and gold are more fre-

[1] Metallic Alloys, p. 87.

quently employed than all others. Alloys containing nickel have become of great importance as well as those in which aluminum is a constituent.

Mr. Brannt recommends for experimentation that metals be added to each other in certain quantities by weight, that is, according to their atomic weights, and claims that in this manner alloys of determined, characteristic properties are, as a rule, produced; or, if such does not answer the demands of the alloy, the object may be obtained by taking two, three, or more equivalents of the metal, exception being made in the cases of arsenic and such elements.

GOLD.

Aurum.	Symbol, Au.
Atomic weight, 195.7.	Malleability, first rank.
Melting point, 1100° (2012° F.).	Tenacity, fifth rank.
Ductility, first rank.	Specific gravity (cast), 19.265.
Conductivity (heat), 53.20.	Conductivity (electricity), 77.96.

(Silver being 100.)

Occurrence.—Gold is found in nature chiefly in the metallic state, or as native gold, and less frequently in combination with tellurium, lead, and silver. It is also found combined, or, perhaps, more strictly speaking, minutely mixed with pyrites and other sulphides, more commonly called "sulphurettes."

Native Gold occurs rather frequently in crystals belonging to the cubic system, the octahedron being the commonest form, but other and complex combinations have been observed. Large crystals are rarely well defined, owing to the softness of the metal, the points being commonly rounded. The most characteristic forms, however, are the nuggets or pepites. These, when of a weight less than one-quarter to one-half an ounce, are known as gold dust.

Except the larger nuggets, which are usually more or less angular or irregular, gold is generally found in a bean-shaped or somewhat flattened form, the smallest particles being scales of scarcely appreciable thickness, and owing to their small bulk, as compared with their surface, they are frequently suspended in water and may be washed away by a rapid current; hence, they are known as float gold.

In the museum of the Mining Bureau in San Francisco are several plaster-of-Paris models of famous gold nuggets found in the various gold regions of the world. The largest single piece of gold ever found was taken out at Ballarat, Victoria, Australia. It weighed 2166 troy ounces, and was valued at $41,882. The second largest was discovered in the Ural Mountains district, and weighed 1200 ounces. The third largest, which was also found in Victoria, Australia, weighed 1121 ounces, and was valued at $22,000.

The physical properties of native gold are quite similar to those of the melted metal and its alloys. The composition varies considerably in different localities, as shown in the following table:

Analysis of Native Gold from Various Localities.

Locality.	Gold.	Silver.	Iron.	Copper.
Europe:				
British Isles—				
Vigra and Clogau	90.16	9.26	Trace.	Trace.
Wicklow (River)	92.32	6.17	0.78	
Transylvania	60.49	38.74	.....	0.77
Asia:				
Russian Empire—				
Brezovsk	91.88	8.03	Trace.	0.09
Ekaterinburg	98.96	0.16	0.05	0.35
Africa:				
Ashantee	90.05	9.94		
America:				
Brazil	94.00	5.85		
Central America	88.05	11.96		
Titiribi	76.41	23.12	.....	0.87
California	90.12	9.01		
Mariposa	81.00	18.70		
Cariboo	84.25	14.90	.....	0.03
Australia:				
South Australia	87.78	6.07	6.15	
Ballarat	99.25	0.65		

The most important minerals containing gold are:

Sylvanite, or graphic tellurium, $(AgAu)Te_2$, containing 24 to 26 per cent.

Calaverite, $AuTe_2$, containing 42 per cent.

Nagyagite, or foliate tellurium, of a complex and rather indefinite composition, and containing from 5 to 9 per cent. only of gold.

The calaverite, a nearly pure telluride of gold, has been found to some considerable extent in Calaveras County, California.

The minerals of the second class, called auriferous, are comparatively numerous, and include many of the metallic sulphides. The most important of these are iron pyrites and galena; the first of these is of great practical importance, being found in many districts exceedingly rich, and next to the native metal, is the most prolific source of gold.

A Native Amalgam of gold is found in California, but rarely in any considerable quantities.

Gold is so widely distributed throughout the earth's crust that few regions may be said to be destitute of slight traces of it; yet it has been found in comparatively few localities in quantities sufficient for economical extraction. The principal supplies of the metal have been derived from Africa, California, Australia, Mexico, Brazil, Ural Mountains, Transylvania, Alaska, etc.

The association and distribution of gold may be considered under two different heads, namely, as it occurs in mineral veins, and in alluvial or other superficial deposits which are derived from the waste or disintegration of the former. As regards the first, it is usually found in quartz veins or reefs transversing slaty or crystalline rocks, either alone or associated with such metals as iron, copper, tellurium, and rarely

bismuth, or such minerals as magnetic and arsenical pyrites, galena, specular iron ore, and silver ore, and rarely with the sulphides of molybdenum, tungstate of calcium, bismuth, and tellurium minerals.

In the second or alluvial class (placers) of deposits it is associated chiefly with those minerals of great density and hardness, such as platinum, iridum, and other metals of the platinum group, tinstone, chromic, magnetic, and brown iron ores, diamond, sapphire, ruby, topaz, etc., which represent the more durable original constituents of the rocks whose disintegration has furnished the detritus.

Refining Gold.—Unless it can be utilized the accumulation of gold in the form of scraps, filings, etc., in the dental laboratory and operating room frequently becomes a source of considerable loss to the dentist, because he is not familiar with the methods of refining or lacks the necessary apparatus.

Some forms of scrap gold, such as old fillings, need only to be melted with the proportion of silver, copper, or both, to produce the desired alloy. Others, as scrap plate of known carat, may be utilized by simply remelting and rolling.

Old crowns, plates, bridges, mixed filings containing more or less iron from the file, zinc, lead, antimony, and other base metals may be converted into malleable gold by simply roasting with such fluxes as will combine chemically with the base metals and remove them.

Sweepings may be washed and then carried through the same process which is known as "roasting."

The Roasting Process.—A method for rendering brittle gold malleable. This process may be most satisfactorily employed where the approximate carat of the bulk of the scraps is known and the gold is suspected of being unworkable because of the admixture of base metals.

The larger pieces should be removed from the accumulation and the smaller ones with the filings freed from as much iron and steel as possible by a good magnet. All should then be placed in a previously well-boraxed and tested graphite crucible, with the addition of sufficient potassium carbonate to well cover the charge; the object of this addition being to form, when heated, a thin flux, permitting the small particles and filings to sink and accumulte in one mass.

The furnace should be placed beneath a fume chimney or by a window with an outward draught, that the fumes escaping from it during the roasting may not fill the laboratory, thereby endangering the health of the operator and damaging such instruments and tools as may be unprotected. The most convenient place to avoid such results is the fireplace. The furnace may be placed beneath its chimney in such a manner that all fumes will be readily carried off.

When the metal has become thoroughly fused, the refining process may be begun by first adding small quantities of the oxidizing agent, potassium nitrate (KNO_3), accompanied with borax, as needed to properly protect the mass and further the process. The object of the potassium nitrate is to furnish sufficient oxygen to oxidize the contaminating base metals beneath the flux, thus separating them from the gold. As most base metals are easily oxidized under these circumstances, a continuation of this process from ten minutes to one hour and a half, according to the

quantity of material, and the proportion of base metals contained, adding the nitrate and borax as required, and maintaining a state of perfect fusion of the metal, the ingot, when made by pouring into a previously warmed and oiled mold, will be found to be quite malleable.

If, however, upon examination it is found to be still brittle, it should be placed in a clean, boraxed, and tested crucible, heated, and brought to a perfect state of fusion. A mixture of equal parts of finely pulverized vegetable charcoal and ammonium chloride should then be added; at first sufficient to properly cover and protect the molten mass and afterward a small quantity at a time as it is needed. When the metal has been sufficiently treated, which may be determined by removing small quantities and subjecting them to the physical tests for malleability, the crucible is to be removed from the furnace and the metal cast into an ingot or allowed to cool in the crucible as a button. The rationale of such a process is that the heat of the crucible breaks up the chloride compound, liberating the chlorine in the nascent state; which in turn combines with the metals lead, tin, and silver contained in the gold to form their respective chlorides. These are either volatilized or taken up by the flux, the gold remaining free of them.

Mercuric chloride is sometimes used when the contamination of the gold with lead or tin is extensive, or where it is desired to remove a quantity of silver. But its use is so dangerous on account of the fumes evolved it is rarely employed.

Sulphur or antimonic sulphide is used to abstract large quantities of silver from gold, by combining with the former to form the fusible sulphide of silver, leaving the gold free, or if the antimonic sulphide has been used, contaminated with antimony, which may be removed by fusing with borax and potassium nitrate, as previously described.

In the process of refining by fluxes, the first step should be to determine, as far as possible, the nature of the debasing elements; this being known or reasonably approximated, the process may be confined to the particular flux most likely to free the gold from its contamination. Iron, steel, zinc, copper, antimony, and bismuth are perhaps, best removed by oxidation through the agency of potassium nitrate. Lead, tin, and silver are removed by chlorine.

If, after such treatment, the alloy is found to be malleable, but stiff or elastic, or dull in color, it very probably contains some platinum which cannot be removed by this means, but which may be gotten rid of by a wet method. When desired, such an alloy may be made direct use of as clasp gold.

When the object is to produce pure gold from which to subsequently prepare desired carats by alloying the results, it is best and most conveniently attained by the process known as "parting gold."

Parting Gold.—A wet method for refining gold by inquartation, or "quartation," as it is more commonly called, is known as the process of parting gold. This is accomplished by digesting the thinly rolled or granulated alloy of silver and gold in either nitric or sulphuric acid.

In the choice of metal for this operation, an endeavor should be made to obtain gold containing as much silver as possible, and, as this

will require an additional quantity of the latter metal fused with it in order to carry out the operation, it is of course an object, if possible, to employ silver which contains small quantities of gold, and thus, to carry on a double refining process at once.

As the actual separation of the two is effected by digesting the mixture in hot nitric acid, which, while it is a ready solvent for other metals, is inactive upon gold, it may be asked: Why not at once treat the alloy with acid without such alloying? Such would be quite useless, for, the foreign metals being in so small a relative proportion, the acid would only remove the alloy at or near the surface, the metal being sufficiently close in texture to mask all the rest from the action of the acid.

The sulphuric acid process is doubly recommended, especially when large quantities of the alloy are to be digested, as it is less expensive, and the gold is obtained of a greater degree of fineness. The oxidizing action of the nitric acid is of especial value, however, when tin or antimony is present in the batch of metal.

Preparation of the Alloy.—The impure gold is first weighed and the approximate weight of the silver, if it contains any, subtracted; silver is then added in the proportion of three to one, less the amount already contained in the alloy, thus when melted forming an alloy of three parts silver and one part impure gold. Hence the term "quartation." These proportions are then fused together in a clean and boraxed crucible, well mixed, and either poured into warmed and oiled ingot molds, to be subsequently rolled, or dropped while molten from the crucible into a wooden tub or tank of cold water for the purpose of granulation. The latter is unquestionably the simplest method of preparing it for the digesting process, for, if poured into the ingot molds, the alloy will require rolling to a very thin ribbon (No. 35 gauge), after which it must be cut into small pieces. Rolling it many times is impossible because the gold that it is desired to refine is exceedingly brittle. The alloy being thus prepared, is ready for the acid.

Nitric Acid Process.—For this process the prepared alloy is placed in a Florence flask and nitric acid to the amount of about one and one-half times the weight of the alloy poured on. The acid should always be tested for chlorine by adding a drop of a solution of silver nitrate ($AgNO_3$) to it, which, if chlorine be present, will instantly be rendered milky from the precipitated chloride of silver. Heat the flask gently in a sand bath over a Bunsen or alcohol flame. Copious red fumes of the oxides of nitrogen and ammonium will be given off, showing vigorous action on the alloy, and the silver and other metals will be dissolved, leaving the gold in a spongy mass of a blackish-brown color. When this evolution has entirely ceased and the flask is clear, carefully decant the solution of the nitrates of silver, etc., thus formed and preserve it, adding a fresh portion of nitric acid and boil until all fumes cease to rise, which marks the termination of the digesting process. The acid is now replaced by distilled water two or three times, for the purpose of washing the gold remaining. At length filter the contents of the flask, catching the gold on the filter paper, add a sufficient quantity of potassium carbonate, fold the paper over the whole, and place in a previously boraxed crucible, melt and pour into warmed and oiled ingot molds.

Gold thus refined may reach $\frac{998}{1000}$ fineness, and is ready for any desirable alloying.

For the recovery of the silver, see that subject.

Sulphuric Acid Process.—The use of sulphuric acid for the operation is preferred by many. For, as was stated, it is more economical; and the gold so refined is more thoroughly freed from silver; indeed, it is said that gold having been previously refined by the means of nitric acid may be freed of still more silver by this acid. In operating the metals are so mixed that the gold amounts, at most, to not quite half the weight of the silver; and if copper is contained (which in small proportions facilitates the operation), it should be under 10 per cent., for if too much be present, a large quantity of sulphate of copper will be formed, which latter is insoluble in the strong acid liquors. The process may be employed for silver containing very small quantities of gold Thus, in France, it was found very profitable to separate the gold from old five-franc pieces, which contained only $\frac{1}{1000}$ to $\frac{2}{1000}$ of gold.

The alloy having been granulated, as before described, is introduced into a digester (Florence flask) with about two and one-half times its weight of concentrated sulphuric acid. This is allowed to boil, during which strong action is evidenced by copious evolution of sulphur dioxide, while the silver and copper are simultaneously converted into sulphates. This first boiling is continued as long as sulphur dioxide is evolved, which in large quantities of metal will commonly go on about four hours. The liquid is then removed and a smaller quantity of acid added, the boiling being further carried on for a short time, after which the digester is allowed to remain at rest, in order that the gold may subside. Sometimes it may be necessary to make even a third addition of acid.

Repeated washing of the gold with boiling water is now necessary, as the sulphate of silver is a very insoluble salt, and sulphate of copper, when contained in so acid a menstruum, is also somewhat so. The gold is then dried, melted, and poured, as described before.

This process affords gold as pure as $\frac{998.5}{1000}$.

The Preparation of Chemically Pure Gold.—The metal, either in the form of powder, granulations, thin plate, or "cornets" from the purest gold that can be obtained, is dissolved in chemically pure nitro-hydrochloric acid.[1] The best material to operate on is gold which has been refined in the ordinary way; this may be used in the form of a powder, as it is precipitated in the last process, as granulations or as plate. The acid for small quantities is best contained in an evaporating dish placed in a sand bath upon a tripod, over the flame of a Bunsen burner, beneath a chimney or near an open window. The action will be tolerably energetic when the metal is first introduced; hence, it is not necessary to ignite the burner at the start, but as the action slackens a moderate heat may be applied.

Instead of previously mixing the acids, the hydrochloric acid may first be poured over the metal, and the nitric acid afterward gradually added in small portions, the function of the nitric acid being to oxidize the hydrogen of the hydrochloric acid, converting it into water, while

[1] One volume of nitric to two of hydrochloric acid (or any proportion, so the latter is in excess).

the chlorine, which is the active solvent, is liberated in the nascent state and unites with the gold, converting it into auric chloride, which dissolves.

Each ounce of gold will require about three and one-half ounces of mixed acid for its solution. During the processs of solution a sediment will be noticed in the bottom of the evaporating dish, which will be recognized by the operator as a silver chloride, formed by the union of the silver contained in the gold and the liberated chlorine. It must not be expected that all the silver will be directly precipitated to the bottom as a chloride, for the liquor is strongly acid, and some may be held in solution. Therefore, this must be taken into consideration, and subsequent pains taken to throw it down by the thorough evaporation of the nitric acid. The gold having been dissolved, the solution is now best transferred to a clean dish by decantation, leaving the chloride of silver in the first and the solution contained in the second dish heated to further evaporate. When about one-third is evaporated more chloride of silver will be found to have been separated from the solution and precipitated. It is well, therefore, to again transfer the solution to a third dish by decantation and evaporate as before, care always being maintained during the heating not to apply so great a temperature as to decompose the auric salt which adheres to the sides of the dish above the fluid.

As the bulk is reduced over the gentle heat by evaporation, small quantities of hydrochloric acid are to be added from time to time, which has the effect of liberating nitrous anhydride by decomposing the remaining nitric acid in the liquor; these additions must, however, be made very cautiously, for the action produced is very energetic, and, without due precaution, considerable portions of the now rich liquor will be thrown out of the dish and lost. When the liquor has become of a deep-red color, and of the consistency of syrup, it is to be withdrawn from the heat and permitted to rest for a time, when the whole of the auric chloride will crystallize, forming a mass of prismatic crystals.

The bottom of the dish is now carefully wiped off to remove any sand or dirt that may have collected there from the sand-bath, and the dish and its contents immersed in about a half pint of distilled water, acidulated slightly with hydrochloric acid. It is better now to let this solution stand a week, for chloride of silver, although slightly soluble in a very strong and hot acid solution, is separated by dilution, and by allowing this rest, it will completely subside in the vessel. At the end of this time the solution must be filtered to remove any foreign substance, together with the silver chloride. The filtrate will then be seen to be a rich straw-yellow, and the gold it contains is ready for precipitation.

Precipitating the Gold.—The solution is now best contained in a large glass flask, and the precipitating reagent added. As gold is one of those metals which, as a base, combines with very feeble affinities, it is consequently not only very easily separated, but the physical conditions of the precipitate may be much modified and controlled by the nature of the precipitant, as also by the mode of operating. Thus gold may be thrown down in a powder, in scales, in more or less of a crystalline state, in a tolerably compact sheet or foil, or, lastly, in a

spongy condition, much resembling so-called "solila" or "moss fibre." And these states may be attained with some degree of certainty, although the circumstances determining the more compact forms are more difficult.

Spontaneous precipitation may take place to some extent in a vessel of trichloride of gold when exposed to the air; and thus the sides of the vessel containing it will slowly become covered with the deposit. This is probably due to the action of the nitrogen of the air. Many elementary substances will precipitate gold from the trichloride. Most of the lower metals reduce it, some metallic salts throw it down, and many organic bodies readily precipitate it. Thus sugar when boiled in it gives at first a light-red precipitate, which afterward darkens in color.

Practically, however, ferrous sulphate or oxalic acid are the only precipitants used. The oxalic acid is preferred, and is an excellent precipitant.

The gold salt, being in solution, is broken up by the addition of a strong solution of oxalic acid, and the gold is precipitated to the bottom as either a crystalline mass or a leafy foil. It is necessary to add a slight excess, and the whole should be kept at a gentle heat in a sand bath over a flame. Soon after the application of heat some slight bubbling is noticed, a copious evolution of gas takes place, and at the same time the body of the liquid appears filled with most delicate spangles of metallic gold, which become coherent as they descend, and in consequence assume most any one of the forms above mentioned. The gas seen to escape is CO_2, from the compound, oxalic acid. The reaction is of the simplest—an acid on a binary salt—

$$2AuCl_3 + 3C_2H_2O_4 = 6HCl + 6CO_2 + 2Au.$$

The action of this pecipitant is gradual, and capable of much regulation, by the amount and nature of heat employed, while it is also peculiar in being attended throughout by this evolution of gas which rises quickly through the solution, there is produced from the former cause a tendency in the metal to deposit in a crystalline or crystallogranular state; while from the latter a more or less spongy character is given to it; hence it will be readily seen that inasmuch as we are able to modify these conditions, so we can in the same degree influence the molecular nature of the result.

Where ferrous sulphate is used about four times the weight of the gold will be necessary for precipitation. This may be dissolved quickly in hot distilled water and added to the gold solution. The precipitate thrown down is of a brown color, and will, on being gently burnished with the finger-nail, assume that metallic golden lustre characteristic of the metal. The following is the reaction—

$$2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2Fe_2(SO_4)_3 + 2Au.$$

After the solution has fully subsided from the disturbance caused by addition and precipitation a quantity of hot hydrochloric acid may be added, and much of the supernatant liquor removed, either with a siphon or by decantation, and the remainder of the solution and pre-

cipitate poured upon the filter paper. The precipitate is afterward washed with hydrochloric acid, distilled water, aqua ammonia, and again with distilled water. The necessity of this is apparent, especially in the use of ferrous sulphate, as the precipitate will become more or less contaminated with the iron. In the use of oxalic acid this is to remove the copper, as gold precipitated by oxalic acid from an acid solution containing copper is always contaminated with cupric oxalate. It is then also advisable to heat the solution with a slight addition of potassium carbonate, a soluble double oxalate of copper and potassium is formed, and the gold is left in the pure state. Gold may also be precipitated from its acid solution in a state of purity in the form of brilliant spangles by means of hydrogen dioxide, thus—

$$2AuCl_3 + 3H_2O_2 = 6HCl + 6O + 2Au.$$

When the precipitated gold has been carefully washed and rewashed with distilled water and the above-mentioned reagents, it may be dried and placed in a new crucible, previously boraxed, with some potassium carbonate and potassium nitrate, melted, and cast into an ingot. If iron ingot molds are used the gold should be washed after molding in hot hydrochloric acid to remove any trace of metallic or oxide of iron that may by chance have adhered to its surface during the process of casting the ingot.

Properties.—Pure gold is of a rich, beautiful, yellow color, of strong metallic lustre, unalterable in air. It is the most ductile of all metals, but ranks only fifth in point of tenacity. One grain, however, if covered with a more tenacious metal, like silver, forming a composite wire, may be drawn into a wire 550 feet in length, and only $\frac{1}{5000}$ of an inch in diameter. It is also the most malleable of all metals. One grain of it may be beaten into leaves so thin as to cover an area of 75 square inches, being of but $\frac{1}{370000}$ of an inch in thickness.

Very thin leaves of gold appear green in color by transmitted light; but when heated, the light transmitted is ruby-red.

Gold possesses the property of welding cold. Thus, thin leaves, foil, and other forms of gold are more especially adapted to the use of the dentist as a filling material. The small particles are welded together in one perfectly homogeneous mass as the filling is inserted. The finely divided metal, such as that thrown down in the preparation of pure gold from the chloride solution, may be compressed between dies in the form of disks or medals.

The pure metal fuses at 1100° C. or 2012° F., and its alloys at much lower temperatures. When heated much above its melting point it slowly volatilizes and is readily dissipated in vapor by the oxyhydrogen flame.

Pure gold is nearly as soft as lead, in consequence of which articles of jewelry, coin, etc., made from it are alloyed with copper, silver, platinum, etc., to give them the requisite hardness, durability, and elasticity.

The specific gravity of gold cast in an ingot is 19.265; when stamped, 19.31; and that of the precipitated metal from 19.55 to 19.72.

Graham has shown that gold is capable of occluding 0.48 of its volume of hydrogen, and 0.2 of its volume of nitrogen.

Alloys..—Gold very readily unites with most of the metals, forming alloys of varied qualities. When in the pure state gold is too soft for any great use other than for filling teeth; consequently the greater quantity of gold is alloyed with some metal that will increase its hardness and durability, without greatly impairing its more valuable qualities. The metals usually employed for this purpose are silver, platinum, and copper.

Silver and gold are easily mixed together, but do not seem to form definite compounds. Such alloys are more fusible, more ductile, harder, more sonorous and elastic than gold, and are generally of a greenish-white color. One-twentieth of silver is sufficient to modify the color of gold. The alloys of gold and silver are known to jewelers as yellow, green, and pale gold, according to the content of silver.

Copper and gold unite much more readily than silver and gold; indeed, it is reasonable to believe from their behavior that a chemical combination is formed with 76 per cent. of gold and 24 per cent. of copper. Alloys of copper and gold are much harder, tougher, and more easily fused; less malleable and ductile, and greatly changed in color, being of a decidedly reddish tint, depending upon the proportion of copper with which the gold is debased. An alloy of gold 76, and copper 24, as referred to above, is distinctly crystalline and quite brittle; but a larger proportion of either gold or copper restores the malleability of the alloy.

Standard Gold.—The standard alloy of most nations is one of copper and gold. Some contain small quantities of silver, but this is due to imperfect parting of silver and gold, or it may be contained in the copper used for the alloy. The proportion of copper to gold varies slightly in different countries, and such proportions are stated in thousandths; thus, pure gold is one thousand (1000) fine. The following table gives the composition of standard gold, as fixed by the nations mentioned:

Nation.	Gold.	Copper.
United States, France, Germany, Belgium, Italy, Switzerland, Spain, Greece, China, Austrian *Crowns*	900 (Carat 21.6—)	100
Great Britain	916	84
Ducats, Hungarian	989	11
Ducats, Austrian	986	14
Ducats, Dutch	982	18

The first United States gold coins were ten-dollar pieces, coined in 1795; they weighed 270 grains each, and were of 916.666 (22-carat) fineness. Their weight was reduced in 1834 to 258 grains, with 899.225 (21.581-carat) fineness; and in 1837 the present standard of 900 (21.599-carat) fineness was established.

Alloys of gold with copper, or with silver, or with both, are much used in the manufacture of jewelry. When the gold contains copper only it is termed red gold; when silver only, white gold; if the gold contains both metals, the caratation is termed mixed. In many countries a legal standard of fineness is fixed for gold ornaments and jewelry. In England gold is stamped, or Hall Marked, 16, 18, and 22-carat; in France, 18, 20, and 22-carat; in Germany, 8, 14, and 18-carat, and, also, under the term joujou gold, a 6-carat gold used for electroplated jewelry. The purpose of the stamping is to protect the purchaser, who is enabled to know the carat of the gold he is buying.

The following alloys used by jewelers are also of much interest to the dentist:

TABLE OF MIXED CARATATION.—*Brannt.*

Carats.	Parts.		
	Gold.	Silver.	Copper.
23	23	½	½
22	22	1	1
20	20	2	2
18	18	3	3
15	15	3	6
13	13	3	8
12	12	3½	8½
10	10	4	10
9	9	4½	10½
8	8	5½	10½
7	7	8	9

COLORED GOLDS.—*Brannt.*

Parts.					
Gold.	Silver.	Copper.	Steel.	Cadmium.	Color.
2 to 6	1.0	..	..	...	Green.
75.0	16.6	..	..	8.4	"
74.6	11.4	9.7	..	4.3	"
75.0	12.5	..	..	12.5	"
1.0	2.0	..	..	...	Pale yellow.
4.0	3.0	1.0	..	...	Dark "
14.7	7.0	6.0	..	...	" "
3.0	1.0	1.0	..	...	Pale red.
10.0	1.0	4.0	..	...	" "
1.0	...	1.0	..	...	Dark red.
30.0	3.0	..	2.0	...	Gray.
1 to 3	...	..	1.0	...	Blue.

HIGHER CARAT COLORED GOLDS.

Parts.			Color.	Carat.
Gold.	Silver.	Copper.		
15 dwt.	2 dwt. 18 grs.	2 dwt. 6 grs.	Yellow tint.	18 K.
15 "	1 " 18 "	3 " 6 "	Red "	18 K.
1 oz. 16 dwt.	6 "	12 "	Reddish spring gold.	16 K.
1 "	7 "	5 "	Yellow tint	16 K.
1 "	2 "	8 "	Red "	16 K.

Jewelers usually make their solders from the gold upon which they are to be used by the addition of small quantities of copper, silver, or

brass, the latter greatly increasing the fusibility and fluidity. The following are examples:

JEWELERS' SOLDERS.

For 18-carat gold.		For 16-carat gold.	
18-carat gold	1 dwt.	16-carat gold	1 dwt.
Silver	2 grs.	Silver	10 grs.
Copper	1 gr.	Copper	8 "

Carat.—The fineness of gold is also expressed in carats, a twenty-fourth part, formerly the twenty-fourth part in weight of a gold marc. It is now assumed that there are 24 carats in unity; whether the unit be one pound, one ounce, or one pennyweight, it is divisible into 24 equal parts, and each of these parts is called a carat to express fineness. If a quantity of gold is chemically pure, in other words contains no alloying elements, it is, as we have previously explained, 1000 fine; or as each $\frac{1}{24}$ part is gold, it is said to be of 24-carat fineness. If, however, 2 carats, or $\frac{2}{24}$ of the unit quantity are composed of one or more alloying metals, the gold is said to be 22 carats fine; or if 6 carats or $\frac{6}{24}$ of the alloy is debasing metal, the carat is 18 fine, etc. The following table shows the equivalent of each carat in thousandths:

Carats.	Thousandths.	Carats.	Thousandths.
1	41.667	13	541.667
2	83.334	14	583.333
3	125.001	15	624.555
4	166.667	16	666.667
5	208.333	17	707.333
6	250.000	18	750.000
7	291.666	19	791.666
8	333.333	20	833.333
9	374.999	21	874.999
10	416.667	22	916.666
11	458.630	23	958.333
12	500.000	24	1000.000

Gold Plate.—Pure gold is rarely employed in the dental laboratory, except for soldering continuous-gum cases, and in some branches of crown and bridge-work. Its extreme softness and flexibility make alloying absolutely necessary. The latter must be accomplished, however, without practically impairing either its malleability, or pliancy, and at the same time endow it with that degree of hardness, elasticity and strength necessary to resist the stress and wear to which an artificial denture is exposed in the mouth.

Copper and silver are much used to debase or alloy pure gold. It is questionable, however, whether copper should be used as almost universally as it is; indeed, some regard it as exceedingly objectionable. A plate made from a gold alloy containing a large percentage of copper is more easily tarnished, and has a disagreeable metallic taste.

Silver exercises a very benign influence over copper contained in gold plate, controlling the tendency to the disagreeable redness. Equal parts of silver and copper have little or no effect upon the color of gold.

Silver assists in imparting hardness, elasticity, and durability to the alloy, without so far debasing it as copper alone.

Platinum and silver are sometimes used to endow pure gold with the qualities necessary for a dental base; but the labor of swaging is very greatly increased when platinum is contained in the plate.

In order to secure the best results, alloys intended for plate should not be less than 18-carat in fineness, and the alloy should contain as little copper as possible.

The following are some of the formulæ in use for the preparation of alloys for dental bases:

Number of Formula.	Carat.	Parts			
		Gold.	Silver.	Copper.	Platinum.
1[1]	18	18 dwts.	2 dwts.	4 dwts.	
2	18	18 "	3 "	3 "	
3	18	18 "	4 "	1 dwt.	1 dwt.
4[1]	19	19 "	2 "	3 dwts.	
5	19	19 "	3 "	1 dwt.	1 "
6[1]	20	20 "	2 "	2 dwts.	
7[1]	21	21 "	1 dwt.	2 "	
8[1]	22	22 "	18 grs.	1 dwt.	6 grs.
9[2]	18	64½ dwts. ($60).	13 dwts.		
10[1]	18	20 "	2 dwts.	2 dwts.	
11[3]	18	516 grs. ($20).	96.45 grs. (25c. coin).		
12[1]	19	20 dwts.	40 + grs.	25 grs.	
13[1]	20	20 "	20 + "	18 "	
14[3]	20	516 grs. ($20)	10c. coin.		
15[1]	21	20 dwts.	13 + grs.		
16[1]	21	20 "		6 "	$7\frac{5}{7}$ grs.

Clasp Gold.—Gold for clasps, elastic wires, backings, stays, posts, pivots, etc., usually contain a small amount of platinum to give it greater strength and elasticity. The following formulæ are recommended by Professor Chapin A. Harris:

No. 1—20-Carat.		No. 2—20-Carat.	
Pure gold	20 dwts.	Coin gold	20 dwts.
" copper	2 "	Pure copper	8 grs
" silver	1 dwt.	" silver	10 "
" Platinum	1 "	" platinum	20 "

A content of platinum in gold renders the alloy more liable to oxidation, and, says Professor Harris, "This effect is so marked that such an alloy is readily acted upon by nitric acid." It is not probable, however, that the small amount contained in clasp gold would affect its integrity.

Crown Gold.—Gold for crowns should combine strength with good color. Those alloys of a large copper content make exceedingly unsightly crowns on account of their deep-red color. Professor C. L. Goddard recommends the following for alloys the color of pure gold:

No.1—21.6-Carat.		No. 2—21.6-Carat.	
Pure gold	90 parts.	Coin gold	50 parts.
" silver	5 "	Pure "	45 "
" copper	5 "	" silver	5 "

[1] Richardson's Mechanical Dentistry, p. 56.
[2] Johnson Bros.
[3] Professor C. L. Goddard.

Gold Solders.—These are usually alloys of gold, silver, copper, and zinc, and are designed to be a trifle more fusible than the parts to be soldered; this property is conferred upon them principally by the content of zinc (or brass). They should also possess considerable strength; too much base metal, therefore, should not be added, as it will, by oxidizing, tend to very materially weaken the alloys. Their carat should be as high or nearly as high as that of the plate, and their color as nearly as possible the same.

The following formulæ have yielded satisfactory results as gold solders:

No.	Carat.	Parts.						
		U. S. Coin. Gold.	Pure Gold.	Pure Silver.	Pure Copper.	Pure Zinc.	Brass.	Spelter Solder.[1]
1	14	$10.	....	4 dwts.	2 dwts.			
2	14	16 dwts.	....	5 "	3 " 18 grs.			
3	15	6 "	....	30 grs.	20 "	10 grs.		
4	16	....	11 dwts.	3 dwts. 6 grs.	2 dwts. 6 grs.			
5	16+	....	11 " 12 grs.	3 dwts.	1 dwt. 12 grs.	12 grs.		
6	18	30 parts.		4 parts.	1 part.	....	1 part.	
7	18	....	27 parts.	4 "	4 parts.	....	1 "	
8	20	$10.	....	....	....	....	....	20.64 grs.
9	20	....	5 dwts.	12 grs.	6 grs.	....	....	6 "
10	14	(18 K. gold plate formula No. 9.) 20 dwts. Johnson Bros.		2.5 dwts.	20 grs.	35 grs.		

A simple method for making a good solder suitable for the plate upon which it is to be used is: 5 parts of the plate and 1 of brass or of silver solder. In the case of coin gold, or the crown alloy given above, a solder thus made will be exactly 18 carat.[2]

Rules for Computing and Compounding Gold Alloys[3] and Examples.[4]

PART I.

To ascertain the carat of any given alloy, the proportion may be expressed as follows:

As the weight of the alloyed mass is to the weight of gold it contains, so is 24 to the standard sought.

Example.—Gold 6 parts, silver 2 parts, copper 1 part, total 9 parts.

$$\begin{array}{r} 9:6::24:? \\ 6 \\ 9)\underline{144} \\ \underline{\underline{16}} \text{ Answer.} \end{array}$$

Another method when alloyed gold is used in forming the mass, instead of pure gold, is to express the proportion as follows—

As the weight of the alloyed mass is to the weight of the gold alloy used in its composition, so is the carat of the latter to the carat of the former—

[1] Composed of equal parts copper and zinc.
[2] Professor C. L. Goddard.
[3] Rules by Professor George Watt.
[4] Examples by Professor C. L. Goddard.

EXAMPLE.—Harris No. 1 solder:

22-carat gold	48 parts.
Copper	16 "
Silver	12 "
Total	76 "

76:48::22: carat. Ans. 13.9 carat.

PART II.

To reduce pure gold to any required carat, the proportion may be expressed as follows:

As the required carat is to 24, so is the weight of gold used to the weight of the alloyed mass when reduced. The weight of gold subtracted from this gives the quantity of alloy to be added.

EXAMPLE.—Reduce 6 ounces of pure gold to 16-carat, 16:24::6 ounces: 9 ounces. 9 — 6 = 3 ounces alloy to be added.

To reduce gold from a higher carat to a lower carat, the proportion may be expressed as follows:

As the required carat is to the carat used, so is the weight of the mass used to the weight of the alloyed mass when reduced.

The weight of the mass used, subtracted from this, gives the quantity of alloy to be added.

EXAMPLE.—Reduce 4 ounces of 20-carat-gold to 16 carat:

16:20::4 ounces:?

$$\begin{array}{r} 4 \\ 16\overline{)80} \\ \overline{5} \text{ ounces} \end{array}$$

5 ounces — 4 ounces = 1 ounce alloy to be added.

PART III.

To change gold from a lower to a higher carat, add pure gold or a finer alloy.

As the alloy in the required carat is to the alloy in the given carat, so is the weight of the alloyed gold used to the weight of the changed alloy required.

The weight of the alloyed gold used subtracted from this gives the amount of pure gold to be added.

EXAMPLE.—Change 1 pennyweight of 16-carat gold to 18-carat. First subtract 16 and 18 from 24 to find the amount of alloy in each carat.

$$\begin{array}{rr} 24 & 24 \\ \underline{18} & \underline{16} \\ 6 & 8 \text{ :: 1 pennyweight:?} \\ & 1 \\ & 6\overline{)8} \\ & \overline{1\tfrac{1}{3}} \text{ pennyweights.} \end{array}$$

$1\frac{1}{3} - 1 = \frac{1}{3}$ pennyweight of pure gold to be added.

To change gold from a lower carat to a higher carat, by adding gold of a still higher carat.

Substract the lower carat and the required carat each from the highest carat (instead of from 24) and proceed as before.

EXAMPLE.—Change 2 pennyweights of 16-carat gold to 18 carat, by adding 22-carat gold.

First subtract 16 and 18 from 22.

$$\begin{array}{cc} 22 & 22 \\ \underline{18} & \underline{16} \\ 4 & 6 \end{array} : 2 \text{ pennyweights} : 3 \text{ pennyweights.}$$

$3 - 2 = 1$ pennyweight of 22-carat gold to be added.

Tests for Gold in Solution.—Sulphuretted hydrogen or ammonium hydrosulphide throws down a brown precipitate of auric sulphide (Au_2S_3). The second precipitant is not used, however, as the precipitate is soluble in it, as it is also in the alkaline sulphides. Auric sulphide is insoluble in nitric or hydrochloric acid taken separately, but soluble in aqua regia.

Ferrous sulphate and oxalic acid precipitate the gold in the metallic state; it is a brown powder, darker in the instance of the former than the latter, but develops the color and lustre of gold by being burnished with the finger-nail or instrument.

Stannous and stannic chloride give probably the most delicate test for gold by the formation of the purple of Cassius.

If the precipitate formed in the experiment above be dried and heated on charcoal a metallic globule results.

Gold is reduced from many of its compounds by sunlight, and from all of them by more or less heat.

Electrodeposition of Gold. By Simple Immersion.—From an acid solution of gold chloride, the base metals, and silver, platinum, and palladium deposit gold in the metallic state. In the double cyanide of gold and potassium zinc will quickly become gilded; copper, brass, and German silver, slowly, and antimony, bismuth, tin, lead, iron, nickel, silver, gold, and platinum not at all.

Deposition by a Separate Current. The Solution.—There are many solutions prepared for electro-gilding, some being formed by chemical means, others by a separate current from the battery; but whether they are made by chemical or electric process, the best for a thick reguline deposit is the pure double cyanide of gold and potassium.

A cyanide solution may be prepared as follows:

Dissolve 120 grains of pure gold in one ounce of chemically pure aqua regia, thus preparing the chloride of gold as described previously.[1] Dissolve the chloride obtained in 32 ounces of warm distilled water and add to it $1\frac{1}{2}$ ounces of magnesia; the gold is precipitated. Filter and wash with pure distilled water; digest the precipitate in 10 parts of distilled water mixed with 0.75 part of nitric acid to remove magnesia; then wash the remaining oxide of gold with distilled water until the wash water exhibits no acid reaction with test paper. Next dissolve 3 ounces of ferrocyanide of potassium and 6 drachms of caustic potash in 34 ounces of distilled water, add the oxide of gold prepared, and boil the solution about twenty minutes. When the gold is dissolved there remains a small amount of iron precipitated, which

[1] Preparation of Chemically Pure Gold.

may be removed by filtering the solution. The liquid, a fine, clear, golden color, is then ready for use, to be employed either hot or cold, but a better and quicker deposit is nearly always obtained from the warm solution.

In electroplating objects the first essential is a finished surface, which must be made just as it is desired to be when completed. The next is cleanliness. If it be a silver denture or any other metallic object it should first be cleaned of all surface combinations, as oxides, sulphides, etc., by polishing in the ordinary way; then scrubbed with a solution of hot water and soap by means of a brass or steel scratch brush on the lathe; then washed or boiled in a strong solution of caustic potash, afterward washing in distilled water, and finally in an acidulated water to remove all traces of the alkali.

The apparatus is exceedingly simple, consisting of a single battery cell and a glass bowl (preferably of perpendicular sides) to contain the solution. The latter may or may not be adjusted in a water bath, according to whether the operator desires to work his solution hot or cold. Aside from these, connecting and guiding wires, cathode and anode hooks, together with an anode, a thermometer, a scratch brush, etc., are all that will be needed. The article to be plated is suspended by a hook in the solution from the cathode, while a piece of pure gold is hung from the anode to keep up the strength of the solution, the latter electrode being easily determined by the fact that gas is liberated there by the passage of the current through the solution.

When a sufficient coating has been formed the object is to be removed from the bath and burnished by the scratch brush or agate burnisher moistened with a solution of warm water and soap, until the surface is finished as desired.

SILVER.

Argentum.	Symbol, Ag.
Atomic weight, 107.12.	Malleability, second rank.
Melting point, 1040° (1904° F.).	Tenacity, fourth rank.
Ductility, second rank.	Specific gravity, 10.53.
Conductivity (heat), 100.	Conductivity (electricity), 100.

Occurrence.—Silver is widely diffused throughout the earth's crust. It is found chiefly in the United States, Mexico, Peru, and Chile; Austria, Hungary, Norway, and Australia also furnish considerable amounts.

Of the varieties of silver ores the following chiefly are metallurgically important: (1) reguline silver, (2) horn silver, (3) silver glance, (4) silver-copper glance, (5) pyrargyrite, (6) stephanite, and (7) polybasite. Silver is also frequently met with in base metallic ores, as in lead ores and many kinds of pyrites.

Chemically Pure Silver.—Small quantities of this may be easily prepared in the laboratory by dissolving commercial or coin silver in pure dilute (50 per cent.) nitric acid contained in a Florence flask, hastening the action by gentle heating over a sand bath. After the silver has been dissolved, and the solution somewhat cooled, add an equal bulk of distilled water, and filter into a second flask. To the

filtrate add a saturated solution of sodium chloride (common salt) until no more white precipitate of silver chloride is formed—

$$AgNO_3 + NaCl = AgCl + NaNO_3.$$

The flask should then be stopped and shaken for several minutes when, on being allowed to rest, the chloride will quickly fall to the bottom, leaving a clear, supernatant liquid above, which, if copper be present, will be colored a bluish-green. If to this clear supernatant liquid the salt solution be added, the operator is enabled to determine instantly whether all of the silver has been thrown down as the chloride, or not. If so, the clear liquid is decanted off and the chloride washed until the wash water does not assume the slightest tinge of blue upon the addition of ammonia. The chloride is now best transferred to a beaker, or some other wide-mouthed vessel, and about twice its bulk of water, acidulated with about 10 per cent. of sulphuric acid, added. Several small pieces of iron in some form, preferably lath-nails, may now be added to the mixture, and the whole stirred with the closed end of a test-tube. The following reactions then take place, during which ferrous sulphate and hydrochloric acid are formed and silver liberated, thus—

$$Fe + H_2SO_4 = FeSO_4 + H_2, \text{ and}$$
$$2H + 2AgCl = 2HCl + 2Ag.$$

The completion of the reaction is recognized by the changing of the precipitated mass from white to a dark gray, which is the color of the finely divided silver. The small pieces of iron are now removed, the precipitated silver washed and rewashed with dilute hydrochloric acid, then with distilled water, dried, mixed with about an equal bulk of potassium carbonate, and melted in a well-boraxed crucible.

Properties.—Silver is the whitest of metals, very brilliant, tenacious, malleable, and ductile, in the last two qualities being inferior only to gold; if considered weight for weight, it is superior to gold, for while one grain of gold may be beaten so thin as to cover an area of 75 square inches, a grain of silver may be made to cover 98 square inches, though the foil of the former is much thinner than that of the latter. The extent of the malleability of gold and silver has never been absolutely determined, as the means employed have invariably failed before the property in either was exhausted. In tenacity silver is superior to gold. It is also harder than gold, but softer than copper, and is the best-known conductor of heat and electricity. It fuses at 1040° (1904° F.), far below the fusing point of either gold or copper. It volatilizes appreciably at full red heat; in the oxyhydrogen flame it boils, with the formation of a blue vapor. The fused metal readily absorbs oxygen gas (when used under potassium nitrate it takes up as much as twenty times its volume). As the metal cools the oxygen escaping through the semisolid crust on the surface of the fused mass produces very beautiful effects. Pure silver retains a trace of the absorbed oxygen permanently. It is unaltered in the air at any temperature, but is readily acted upon by sulphur, phosphorus, or chlorine.

Nitric acid is the proper solvent for silver, and is most efficient when diluted about 50 per cent., but active whether concentrated or dilute.

with the production of nitric oxide (N_2O_2) and silver nitrate ($AgNO_3$). Sulphuric acid, hot and concentrated, acts upon silver, forming a sulphate which is sparingly soluble. Hydrochloric acid, hot and concentrated, forms argentic chloride. Fused alkaline hydrates or nitre are without action upon silver; hence it is used for the manufacture of crucibles for the fusion of caustic alkalis, etc.

Alloys.—Pure silver is too soft for coinage or commercial purposes; it is, therefore, alloyed variously for its different usages to increase its hardness.

Gold.—Formerly silver was much used to alloy gold. The metals are easily mixed together, but do not appear to form definite compounds. With certain proportions of the metals the resulting alloys are more ductile, harder, more sonorous and elastic than either metal considered singly.

Copper.—The alloys of copper and silver are the most useful of the alloys of silver. In most countries the silver coins are made of these two metals. In the United States the silver for coinage is alloyed with 10 per cent. copper, the proportion of each being stated in the thousandths; thus, pure silver being 1000 fine, the coin or "standard silver" is 900 fine, with 100 parts copper added. The German and French silver coins are of the same grade, those of Great Britain are 925 fine, with 75 parts of copper added, being known as "sterling" silver. Most silverware is of "sterling" fineness. The presence of copper does not modify the color of silver so long as the proportion of the former does not exceed 40 or 50 per cent. Copper imparts to silver greater hardness, tenacity, and strength.

Comparison of the silver dollar of the United States with that of Mexico:

	United States dollar.	Mexican dollar.
Pure silver	371.25 grs.	377.14 grs.
" copper	41.25 "	40.65 "
Total weight	412.50 "	417.79 "

The Mexican dollar weighs 0.866 of a Troy ounce.

Zinc and silver have a great affinity for each other, and are consequently readily alloyed.

Silver solder for soldering the metal is usually composed of an alloy with copper and zinc. The following are well adapted for the porpose:

No. 1.[1]		No. 2.[2]	
Silver . . .	66 parts.	Silver . . .	6 parts.
Copper . . .	30 "	Copper . . .	2 "
Zinc . . .	10 "	Brass . . .	1 part.

"When the material to be united is composed of pure silver and platinum, silver coin alloyed with one-tenth zinc may be used as a solder."

So-called "Standard" silver is also an excellent solder for high fusing brass and German silver. If the article is to be soldered twice, this may be used first and the silver solder afterward.[3]

[1] Richardson's Mechanical Dentistry, p. 78.
[2] Ibid.
[3] Professor C. L. Goddard.

Dr. Kirk[1] recommends the following compositions:

Fine silver.	Copper	Brass.	Zinc.
4.0	...	3.0	...
2.0	...	1.0	...
19.0	1.0	10.0	5.0
66.7	23.3	...	10.0
50.0	33.4	16.6	...
11.0	...	4.0	1.0

These may be used for soldering the surfaces of standard silver.

Electrodeposition of Silver.—Silver is the most important and prominent metal in electroplating processes.

The solution generally used is the cyanide, and it may be prepared by either of two methods—the battery or the chemical process.

The method of procedure in the former is simple, when thoroughly understood. First, the percentage of actual cyanide in the cyanide salt used must be ascertained. If it contains about 50 per cent., dissolve each ounce in about one quart of distilled water; or if it contains more, add more water and vice-versa in proportion. Suspend a large anode and a small cathode of silver in the liquid, and pass a strong current of electricity through until the required amount of metal is dissolved from the anode. As this process produces some caustic potash in the liquid, some of the strongest hydrocyanic acid may now be added to form this into the cyanide, and more of the anode dissolved in the mixture by the battery.

Solutions for deposit are made by the chemical process as follows:

Take four parts of pure grain silver and reduce it to argentum nitrate by mixing with nitric acid. Dissolve this in distilled water, in the proportion of one quart to every one-half ounce of silver used. At the same time make a solution of from two to three parts of cyanide of potassium in twenty or thirty parts of distilled water. This is to be added gradually to the solution of nitrate of silver as long as it produces a white precipitate. If too much be added, however, it will cause some of the precipitate to be redissolved and wasted. In such a case the liquid should be stirred and then allowed to settle clear. A small amount of nitrate of silver dissolved in distilled water should be added as long as it produces a white cloud. This may be better observed by using a separate glass vessel to see the precipitate as it dissolves. The liquid should now be left to settle until quite clear, and the clear portion then decanted, and the precipitate washed four or five times in a large quantity of water by simply adding the water, stirring, and allowing it to settle again, and decanting as before. Next dissolve from six to eight parts of cyanide of potassium in twenty parts of distilled water, adding it a portion at a time, with free stirring, to the wet cyanide of silver, until the whole is barely dissolved; then add about three parts more of cyanide of potassium to form free cyanide, and sufficient distilled water to reduce the whole to the proportion of about one-quarter of an ounce of silver to the quart; finally, when all the free cyanide is

[1] American System of Dentistry, vol. iii. p. 879.

dissolved, filter the solution and it is ready for use. The specific gravity of the solution should be maintained at between 1.8 and 1.15. Deposit solutions are very numerous, but, in the author's judgment, the above is best adapted for a good, reguline solid deposit.

Knowledge of the management of solutions is essential. There are varying circumstances which must be noted in order to keep them in good condition for a reguline deposit. New solutions do not work as well, usually, as old ones, provided the latter are not too old. Solutions of two or three years of age work probably the best. They change from many causes; they become dirty and concentrated from exposure; increase or decrease in their relative proportions of cyanide and metal; they acquire other metals in solution, dissolved from the anode and corroded from the cathode; plaster and plumbago accumulate in them, in consequence of which they should be filtered; they gradually decompose, become brown, discolored, and evolve ammonia by exposure to light, especially if they contain too much free cyanide; therefore, all these deviations from the proper condition should be corrected. The specific gravity should be maintained, and the proper amount of metal and cyanide kept in solution. To determine any disproportion in the latter, place 25 grams of the solution in a test-tube of proper size, and add to it, at first freely, and afterward gradually, at last, drop by drop, with constant stirring, a solution of 1 gram of crystallized nitrate of silver in 10 grams of distilled water. If the precipitate formed is dissolved rapidly, with but little need of stirring, there is too much cyanide. If, however, it does not dissolve, even after much stirring, there is too little cyanide; but if it wholly dissolves (the latter part quite slowly) the proportion of silver to cyanide is about correct.

Many other minor troubles not mentioned are encountered, which must be corrected by means gathered only from experience in working the process.

The processs for making dental bases by electro-deposition on the plaster cast of the mouth was patented February 5, 1889, by Joseph G. Ward, of Irvington, N. J.

The author has had some experience in the work; in fact, was engaged in perfecting a process for the same result when Mr. Ward secured his patent. The method of proceedure in the preparation of a dental base is as follows:

A true impression of the mouth is secured, and from this a cast is obtained by casting in the usual manner. After the cast has become thoroughly dry it should be soaked in hot fluid paraffin, until saturated, and before cooling the surface is wiped clean of all superflous adhesions which might in any way destroy the exactness of the surface. The cast is then coated freely, where the deposit is desired with a mixture of equal parts of pure, finely pulverized plumbago and the finest tin-bronze powder or any other conducting substance which would be suitable for the purpose. This is applied with a thick, short-haired camel's-hair pencil. The cast is now so wired that perfect connection is made with the palatal, buccal, and labial surfaces. From these guiding

wires a cathode hook suspends the cast in the solution. After the metal has been deposited to a sufficient thickness, the cast, with its deposit, is to be taken from the bath, the deposit removed from the cast, trimmed and polished; but if it is desired to have the plate of increased thickness at any part to give the appearance of a turned rim, etc., the cast, with the deposit adhering to it, may be removed from the bath, and all the exposed surface of the deposit, except the portions to be thickened, may be covered with a coating of wax or some other non-conducting substance, and re-submerged in the bath and left there until the required thickness of deposit is secured in the parts desired. It may then be taken from the bath, burnished, trimmed by scraping, burring, and filing to the proper shape and thickness, then polished, and spurred. A thick plating of gold should now be added to the properly shaped plate, or the rubber for the attachment of the teeth will not harden and adhere to the plate during the process of vulcanization (the sulphur of the vulcanite combining with the silver). After the teeth have been attached and the vulcanite and all properly finished, a second coating of gold should be electroplated over it all to cover portions that had been made bare in finishing the vulcanite.

The denture may be made by depositing the metal directly on the teeth as in cheoplastic work, and, where necessary, clasps may be formed. Broken dentures have been soldered with 18-carat gold solder.

Crown and bridge work may also be made in various ways by this process.

PLATINUM.

Platinum.	Symbol, Pt.
Atomic weight, 193.3	Malleability, sixth rank.
Melting point, oxyhydrogen flame, 1770° C.	Tenacity, third rank.
	Specific gravity, 21.46.
Ductility, third rank.	Conductivity (electricity), 18.8.
Conductivity (heat), 8.4.	

(Silver being 100.)

Occurrence.—The ore of platinum, "polyxene," which is a most complex mixture of a number of heavy reguline species of platinum, osmiridium, iron-platinum, platin-iridium, iridium, palladium, gold, and a number of non-metallic species, notably chrome-iron ore, magnetic iron oxide, zircone, corundum, and occasionally also diamond, is found in the province of Choco, South America, where it was first discovered in 1736, in New Granada, Barbacos, California, and Australia, but chiefly in alluvial deposits in the Ural district in Russia.

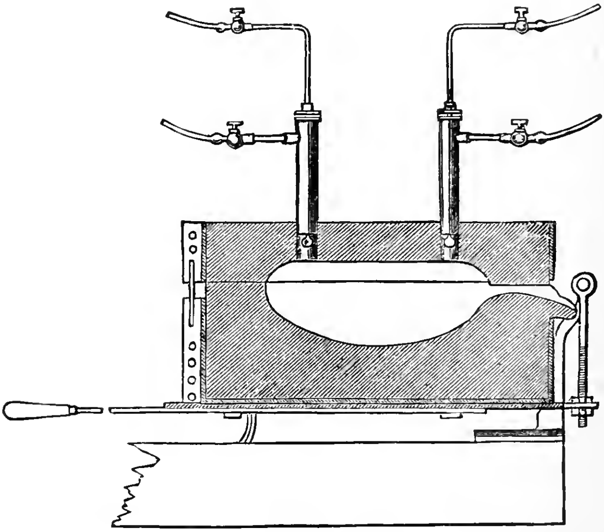
Fusing Platinum.—By means of the oxygen blowpipe the spongy platinum is easily reduced to a compact mass, a result formerly only fairly well obtained by the very tedious and laborious means of welding.

The furnace for fusing platinum (Fig. 114) is at once a cupel and furnace, consisting of two thoroughly burned lime blocks with a basin-like concavity in each, and fitted one over the other. The concavity in the lower block forms the bed of the furnace, and is provided with a gutter leading from the basin to the outside. Through the top are

passed the oxyhydrogen blowpipes. These each consist of two concentric tubes, a small inner and a larger outer tube. Through the outer, or larger, tube the hydrogen or illuminating gas is passed, and through the inner, or smaller, the oxygen is forced into the centre of the flame. The tubes are of copper, tipped with platinum.

Platinum scraps are melted by first heating up the furnace and then introducing them through an opening in the side. In the case of platinum sponge the mass is introduced before heating up the furnace, and it is here that the furnace acts as a cupel; the impurities remaining in the metal are oxidized and volatilized or absorbed by the lime of the furnace. The temperature produced is supposed to be about 2870° C. Osmium does not melt at this point, but if present it is volatilized with palladium and gold.

FIG. 114.



Furnace for fusing platinum.

Properties.—The metal is bluish silver-white, about as soft as pure copper, and has a specific gravity of 21.46. It is tough, ductile, and malleable, and may be rolled or beaten into foil or drawn into wire of almost microscopic fineness. Dr. Arendt states that a cylinder of platinum one inch in diameter and five inches long may be drawn into a wire sufficiently long to encircle the earth at the equator. The fine wire used in the micrometer eye-piece of microscopes suggested by Wollaston is made by drawing a composite wire of platinum coated with silver to its greatest attenuation, and then dissolving off the silver in nitric acid. Platinum possesses tenacity in a high degree, being slightly inferior to iron and copper. The fusing point, according to Violle, is 1779° C. When heated much above its fusing point, it soon begins to volatilize. The fused metal, like silver, absorbs oxygen, and consequently "spits" on freezing. At a red heat it "occludes" hydrogen gas. The volume of hydrogen absorbed by a unit volume of

metal at a red heat, under one atmosphere's pressure, was found, in the case of the fused metal, to vary from 0.13 to 0.21, volume measured cold; in the case of merely welded metal from 2.34 to 3.8 volumes. Oxygen, though absorbed by the liquid, is not occluded by the solid metal at any temperature, but when brought in contact with it at moderate temperatures, suffers considerable condensation at its surface, and in such a state exhibits a high degree of chemical affinity. When a jet of hydrogen gas strikes a layer of spongy platinum it causes it to glow and the gas takes fire.

The most striking example of the property of the metal for absorbing gases is demonstrated in the finely divided state known as "platinum black." This state is produced by dropping platinum chloride solution into a boiling mixture of 3 parts of glycerin and 2 of caustic potash. Platinum black is said to absorb 800 times its volume of oxygen from the air, and is, therefore, a most active oxidizing agent, acting catalytically—*i. e.*, after having given up its oxygen to the oxidizable substance it takes up a fresh supply from the atmosphere.

Platinum is not dissolved by any single acid, its proper solvent being nitrohydrochloric acid.

The caustic alkalis, the alkaline earths, nitrates and cyanides, and especially the hydrates of barium and lithium, attack platinum at a red heat, although the alkaline carbonates have no effect at the highest temperatures. Sulphur, in the absence of alkalis, has no action, but phosphorus and arsenic attack platinum when heated with it.

Direct contact of platinum with burning charcoal should be avoided, since the silicon reduced from the charcoal ash unites with platinum, making it brittle and liable to fracture.

Heating platinum with spirit lamps is preferable to the use of ordinary gas. When gas is used, care should be taken to have the supply of air sufficient to ensure complete combustion, since, with the flame containing free carbon, the platinum suffers deterioration by the formation of a carbide of platinum. For this reason, also, the inner cone or reducing flame should not come in contact with the metal.

Platinum was introduced in France as early as 1820 for a base in continuous-gum work. Its low rate of expansibility under increased temperature, its coefficient being about equal to that of glass, and its very high fusing point make it most useful as a base for porcelain work, and for pins for artificial teeth. Its comparatively great resistance to chemical agents ensures it against corrosive action, and places it on an equality, in this particular, with gold for dental bases, crowns, and bridge work.

Coils of platinum wire are useful in dental offices in various forms of electric heating devices. The heat is free from products of combustion and can be most accurately controlled. A device of this nature is especially valuable in annealing gold.

Alloys.—Platinum alloys with most of the metals. With mercury spongy platinum unites to form an exceedingly unctious amalgam. It does not unite readily, and its union is best accomplished by continuous rubbing in a warm mortar.

Iridium from 10 to 15 per cent. added to platinum greatly increases its hardness, elasticity, infusibility, and resistance to chemical action. Platinum alloyed with iridium can be made very useful in dentistry to strengthen weak parts of partial continuous-gum, partial vulcanite dentures, and crown and bridge work.

An alloy of 78.7 platinum and 21.3 iridium will withstand the action of aqua regia. Equal parts of the metals form a very brittle alloy.

Gold and platinum form an alloy of great value for the construction of dental bases. Platinum gives to gold a greater hardness and elasticity. Two parts to one of gold forms a brittle alloy, while with equal parts the alloy is malleable. Prinsep found that 7 parts of gold and 3 parts of platinum formed an alloy infusible in the strongest blast furnace. Gold 11 parts and platinum 1 part form a grayish-white alloy, having somewhat the appearance of tarnished silver.

Gold 75 parts and platinum 25 parts form an alloy much used in continuous-gum and porcelain crown and bridge work. It is usually called 25 per cent. platinum solder.

By small additions of platinum to silver its pure-white color is changed to a gray, and its hardness is increased. The alloys are difficult to make, on account of the separation of the platinum, owing to its greater specific gravity.

Platine au titre, an alloy composed of from 65 to 83 per cent. of silver, has been used for dental bases in preference to coin silver, on account of its resistance to chemical action and its greater elasticity. Nitric acid will dissolve an alloy of silver and platinum when the latter is not present, to exceed 10 per cent.

Cadmium and platinum unite, to form a definite compound, having the formula of $PtCd_2$.

Copper and platinum, equal parts, form a gold-colored alloy tarnishing in air.

Lead and tin unite with platinum in all proportions, resulting in hard and brittle alloys of low fusing points. Pure platinum should, therefore, never be brought in contact with these or other low fusing metals or their alloys at high temperatures, as alloys with platinum having a low fusing point and brittle character are readily formed.

IRIDIUM.

Iridium.	Symbol, Ir
Atomic weight, 191.5.	Malleable, at red heat.
Melting point, oxyhydrogen flame.	Specific gravity, 22.40.
Conductivity (heat).	Conductivity (electricity).

Silver being 100.

Occurrence.—This metal occurs chiefly as a native alloy of iridium and osmium, known as osmiridium or iridosmine. It is also found thus combined with platinum, and is contained in gold from several localities, especially that from some mines of California and in the Frazer River district of British Columbia, causing much inconvenience.

Properties.—Iridium is a steel-white metal, exceedingly hard, brittle when cold, but somewhat malleable at red heat, having a specific

gravity of 22.40, unaltered in air, and fusible only in the oxyhydrogen flame. If the precipitated metal be moistened with a small quantity of water, pressed tightly between filter paper, and then very forcibly in a press, and calcined at a white heat, it may be obtained in the form of a very hard compact mass, capable of taking a good polish, but still very porous, and having a specific gravity not exceeding 16.

The pure metal itself is not acted upon by the acids, but when reduced by hydrogen at a low temperature it oxidizes slowly at a red heat, and may be dissolved in nitrohydrochloric acid.

Alloys.—With gold iridium forms a malleable and ductile alloy, its color depending upon the proportions of the metals.

Platinum and iridium form some very valuable and useful alloys.[1] Aside from these, and the use of the metal and its alloy with phosphorus for pointing gold pens, iridium is of little value.

With silver it is claimed there is no alloy, and that after exposing a mixture of these metals to a high temperature, or attempting to pour out the contents of the crucible, silver alone flows out and a thick mass is left in the crucible.

MERCURY.

Hydrargyrum.	Symbol, Hg.
Atomic weight, 198.5.	Malleable at —39° C.
Melting point, —39° C.	Ductile at—39° C.
Boiling point, 357.3° C.	Specific gravity, 13.595.
Conductivity (heat), greater than water.	Conductivity (electricity), 1.49.

Silver being 100.

Occurrence.—Mercury occurs in nature chiefly as the red sulphide, HgS, cinnabar, which, as a rule, is accompanied by more or less of the reguline metal. The most important mercury mines of Europe are those of Almaden, Spain, and of Idria, in Illyria; it is also found in China, Mexico, Corsica, Peru, and California. The European mines, until lately, furnished the bulk of the mercury of commerce, but they have been eclipsed by the rich deposits of New Almaden, near San José, California. The mines of the latter have been the most productive in the world, yielding more than 3,000,000 pounds annually, and large quantities are still taken from them. The California cinnabar is richer in mercury, because purer, than the Spanish, the former yielding about 70, the latter about 38 per cent. of mercury.

Mercury is also found free, forming an amalgam with silver, and in the form of protochloride (native calomel).

Properties.—Mercury, or quicksilver, as it is often called, is of a silver-white color, liquid at ordinary temperature (above —39° C.), odorless, and tasteless. Volatile at common temperature, but more rapidly volatilizes as the temperature increases, and at 357.3° C. it boils, being finally volatilized without residue. When globules are dropped upon white paper they should roll about freely, without tailing, retaining their globular form. It should be perfectly dry, and present a bright surface. When perfectly pure it undergoes no alteration by

[1] See Platinum.

the action of the air or of water, but in the ordinary state it will exhibit a slight tarnish. It solidifies at —39° C. with considerable contraction into a compact mass of regular octahedra, which can be cut with a knife or flattened under the hammer.

Action of Acids on Mercury.—Hydrochloric acid does not attack mercury. Sulphuric acid, boiling, converts it into mercurous sulphate, liberating sulphur dioxide.

Nitric acid is the most effective solvent for mercury. It dissolves readily in the dilute acid if heated, or in the cold, if nitrous acid is present; with the strong acid, heat is soon generated, and with considerable quantities of the material the action acquires an explosive violence. At ordinary temperatures, dilute nitric acid, when applied in slight excess, produces chiefly normal mercurous nitrate, but when the mercury is in excess, more or less basic mercurous nitrate is formed; hot dilute nitric acid, in excess, forms chiefly mercuric nitrate; when the mercury is in excess, both basic mercurous and basic mercuric nitrates are formed. In all cases, chiefly nitric oxide gas is evolved.

Alloys.—Mercury unites readily with most metals except iron and platinum. With the former it has been found to unite only indirectly; for example, by rubbing very finely divided iron with mercuric chloride, water, and a few drops of metallic mercury. The latter metal can only be combined in the spongy state. Yet both of these metallic elements combine chemically with mercury to form definite compounds, according to Bloxam and other authorities, and present the composition FeHg and $PtHg_2$ respectively.

Vermilion.—Mercuric sulphide, HgS, occurs native as cinnabar, a dull-red mineral, the most important ore of mercury. It may be prepared by several different methods, much depending upon the purity of the materials employed. When mercury and sulphur are heated together their union is accompanied with much energy, and if the product be sublimed the red or mercuric sulphide is obtained. The sulphur is first melted and the mercury gradually added by straining through linen cloth, whereby it falls in a minutely divided state, while the mixture is constantly stirred. When the temperature arrives at a certain point, the combination takes place suddenly with a slight explosion, attended with the inflammation of the sulphur, which must be extinguished by covering the vessel. The product of the combination is a black mass, generally containing an excess of sulphur, which, before the sublimation is performed, should be gotten rid of by gentle heat on a sand bath. Sublimation is best carried on in a closely stopped glass matrass, which should be placed in a crucible containing sand, and, when thus arranged, exposed to a red heat. The resulting vermilion is reduced to a fine powder by levigation, the beauty of the tint depending much upon the extent to which the division is carried.

It is prepared in a wet way by intimately mixing 100 parts of mercury with 38 parts of the flowers of sulphur, and the black sulphid of mercury thus obtained digested, with constant agitation, in a solution of 25 parts of caustic potash in 150 parts of water at 45° C. (the water lost by evaporation being constantly replaced), until the pre-

paration has come up to its maximum of fire and brilliancy, which takes a good many hours. Purely sublimed vermilion has a comparatively dull color, and must be manipulated with an alkaline (potassium) sulphide solution to give it the necessary fire. The action of the alkaline sulphide consists probably in this, that it dissolves successive installments of the amorphous preparation and redeposits them in the crystalline form.

Properties.—It is a fine, bright-scarlet powder, permanent in air, odorless and tasteless, insoluble in water, alcohol, dilute nitric, concentrated hydrochloric, or sulphuric acids. Nor is it acted upon by boiling potassium hydrate, sulphide of ammonium, cyanide of potassium, or sulphite of soda. It is slightly acted upon by concentrated hot nitric acid, and completely soluble in a solution of potassium sulphide in the presence of free alkali or a solution of sodium sulphide. Nitro-hydrochloric acid decomposes it into mercuric chloride, which is readily soluble. It may be completely sublimed, as has been seen, without decomposition, but if exposed to a temperature of 315.5° C. (600° F.) it is decomposed into metallic mercury and sulphur dioxide. It is frequently adulterated with red lead, dragon's blood, chalk, ferric oxide, realgar (As_2S_2), and brickdust. If lead be present it will yield a yellow precipitate when digested with acetic acid and potassium iodide added. Dragon's blood may be detected by alcohol, which will take up the coloring matter of that substance if present. Chalk is detected by an effervescence on the addition of an acid. Most other impurities may be detected by subliming a small portion of the compound. The non-volatile substances used for adulteration will remain behind.

Uses.—When pure it is much used as a pigment, on account of its brilliancy and color. Its unalterableness and resistance to chemical action render it particularly valuable in giving the red color to vulcanizable rubber used in the construction of artificial dentures of red and pink vulcanite, in the composition of which it forms, in some cases, about one-third of the entire weight of the compound. Notwithstanding the poisonous character of mercurial compounds in general, and the frequency of troubles of an inflammatory nature of the mucous membrane in mouths fitted with rubber dentures, it is obviously very improbable, when we consider the properties of pure vermilion, that such conditions can be in any degree attributable to the presence of this substance *per se*. It is quite possible that impure vermilion may contain from the start free mercury; be contaminated with arsenic bisulphide, or poisonous adulterations. Again, the practice of dissolving tin-foil off of the surface of plates with nitro-hydrochloric acid just after vulcanization may possibly decompose some little vermilion, forming soluble bichloride. It is highly improbable that any of these conditions can be found, yet it is possible. It is said that free mercury has been observed with the microscope in finished vulcanite. The occurrence of oral inflammatory conditions, under black rubber dentures, precisely similar to those under red rubber, practically relieves vermilion of the responsibility. Such inflammatory troubles are directly

attributable to its rough and porous surface, lack of cleanliness on the part of the wearer, and the fact that rubber is a non-conductor of heat.

ALUMINUM.

Aluminum.	Symbol, Al.
Atomic weignt, 269.	Malleability (said to equal silver).
Melting point 625° (1157° F.)	Tenacity, fourth rank.
Ductility, eighth rank.	Specific gravity, 2.583.
Conductivity (heat), 100.	Conductivity (electricity), 100.

(Silver being 100.)

Occurrence.—With the exception of silicon and oxygen, aluminum is the most abundant element in the earth's crust. It is never found in the free or metallic state, but occurs combined with silicon and oxygen, as marl, clay, slate, pumice-stone, feldspar, mica, and nearly all rocks, with the exception of limestone and sandstone. As the crystallized oxide—alumina—it occurs as corundum (Al_2O_3), emery, ruby, sapphire, emerald, topaz, and amethyst, which are used as gems. The metal is further found in combination with nearly two hundred different minerals.

Properties.—Aluminum is a bluish-white metal, somewhat resembling silver in appearance. It is also said to be as malleable, of the same tenacity, and equal to that metal in the conduction of heat and electricity. It is harder than tin, but softer than copper. By hammering in the cold it may be made as hard as soft iron, but is softened again by fusion. It is remarkably sonorous, and has been used for making bells. It is one of the lightest of metals, being approximately only two and a half times heavier than water, and four times lighter than silver. It fuses at 625° C., or about 1157° F.; does not oxidize in air, even at a red heat; has no action on water at ordinary temperatures, nor is it acted upon by the compounds of sulphur, thus preserving its lustre where silver would be tarnished and blackened. It is without odor or taste.

Aluminum may be melted in an ordinary clay crucible, no flux being needed. Borax is not only useless, but is actually harmful, as aluminum readily attacks the glasses. Biederman recommends dipping the scraps which are to be melted together in benzine before putting them in the crucible. Should any be contaminated with solder this may be removed by nitric acid, which does not act upon aluminum.

Alloys.—Aluminum alloys with nearly all metals, except lead; indeed, the wonderful alloys it is capable of producing gives it, perhaps, its greatest value.

Aluminum may be melted in a graphite crucible without flux, but great care must be taken not to heat it too hot. On account of its high specific and latent heat, aluminum requires a long time to melt; but, unlike some other metals, it soon becomes fluid after the melting point is reached.

Gold and aluminum unite, forming a hard and brittle alloy. One per cent. of aluminum in gold destroys the ductility of the noble metal and gives it a greenish cast; 5 per cent. of aluminum with gold yields

an alloy brittle as glass, and 10 per cent. of aluminum produces a white, crystalline, and brittle alloy.

Nürnberg gold, an alloy, for cheap goldware, very much resembling gold, and unchanged in air, is composed of aluminum 7.5, gold 2.5, and copper 90 parts.

Silver and aluminum readily unite, forming alloys of beautiful whiteness, and unchangeable on exposure to air. Their hardness is considerably greater than aluminum, but they are more easily worked. An alloy of 100 parts of aluminum and 5 parts of silver differs but little from pure aluminum, save that it is considerably harder and takes a beautiful polish. An alloy of aluminum 169 parts and silver 5 parts possesses considerable elasticity, and has been recommended for watch springs, dessert and fruit knives. Equal parts of the two metals produce an alloy equal in hardness to bronze.

Copper and aluminum for some exceedingly important alloys, differing according to the quantity of aluminum they contain. Those of a small content of copper cannot be used industrially. With 60 to 70 per cent. of aluminum they are very brittle, glass-hard, and beautifully crystalline. With 50 per cent. the alloy is quite soft; but under 30 per cent. of aluminum the hardness returns. The usual alloys are 1, 2, 5 and 10 per cent. of aluminum. These are known as aluminum bronze. The 10 per cent. bronze has a bright golden color and keeps its polish in air; it may be easily engraved, shows a greater elasticity than steel, and can be easily soldered with 18-carat gold solder. When first made it is brittle, acquiring its best qualities after three or four meltings, after which it may be melted several times without sensible change. It casts well in sand molds, but shrinks greatly. It has a specific gravity of 7.68, about equal to soft iron. Its strength when hammered will equal that of the best steel. Annealing makes it soft and malleable. It does not clog a file, and may be drawn into wire. It melts at about 1700° F.

Aluminum bronze as a base for artificial dentures: "In the proportion of aluminum 100 and copper 900 it oxidizes but superficially in the mouth, and is as strong and resistant to attrition as 18-carat gold; it may be swaged as easily as 20-carat gold, but it must be annealed frequently, and it is necessary to carry the heating almost to whiteness, for if the bronze be merely heated until it assumes a dark-red color it remains as hard as before." (Professor Sauer.)

The alloys of copper and aluminum are prepared in the Cowles' electric furnace by fusing together the oxides of aluminum and metallic copper with enough carbon and flux to reduce them. The oxides and other materials thould be as finely divided as possible.

Solders.—The difficulty of soldering aluminum prevented the metal from being applied to many useful purposes for some time. The solder recommended for general use in the manufacture of articles of ornamentation is composed of copper, 4 parts; aluminum, 6 parts; zinc, 90 parts. The use of this requires some skill and experience; no borax is used and the adhesion is induced by the friction of small aluminum tools. The following alloys may be used as solders for articles of jewelry made of 10 per cent. aluminum bronze:

HARD SOLDER.

Gold	88.88 per cent.
Silver	4.68 "
Copper	6.44 "

MEDIUM HARD SOLDER.

Gold	54.40 per cent.
Silver	27.00 "
Copper	18.00 "

Mr. Wm. Frismuth, of Philadelphia, recommends the following solders for aluminum, with vaselin as the flux:

SOFT SOLDER.

Pure block tin	from 90 to 99 parts.
Bismuth	" 10 " 1 "

HARD SOLDER.

Pure block tin	from 98 to 90 parts.
Bismuth	" 1 " 5 "
Aluminum	" 1 " 5 "

Schlosser recommends the following for dental laboratory use:

PLATINUM-ALUMINUM SOLDER.

Gold	30 parts.
Platinum	1 part.
Silver	20 parts.
Aluminum	100 "

GOLD-ALUMINUM SOLDER.

Gold	50 parts.
Silver	10 "
Copper	10 "
Aluminum	20 "

O. M. Thowless has patented the following solder for aluminum and the method of applying it:

Tin	55 parts.
Zinc	23 "
Silver	5 "
Aluminum	2 "

First melt the silver and aluminum together then add the tin and zinc in the order named. The surfaces to be soldered are immersed in dilute caustic alkali or a cyanide solution, and then washed and dried. They are next heated over a spirit lamp, coated with the solder, and clamped together; small pieces of solder being placed at the points of union, the whole is then heated to the melting point. No flux is used.

The following are useful as solders:

	I.	II.	III.
Zinc	80 parts.	85 parts.	92 parts.
Aluminum	20 "	15 "	8 "

The flux used in soldering is composed of 3 parts balsam of copaiba, 1 part Venetian turpentine, and a few drops of lemon-juice. The soldering iron is dipped into the mixture. So far, the soldering of aluminum in the dental laboratory is very difficult and unsatisfactory.

Another solder for aluminum, recommended by the *Scientific American,* is composed of the following:

Cadmium	50 parts.
Zinc	20 "
Tin	30 "

The zinc is first melted in a suitable vessel; then the cadmium is added, and then the tin, in small pieces. The proportions of the various ingredients may be varied, in accordance with the use to which the article is put. For instance, when a strong and tenacious soldering is required, a larger proportion of cadmium can be used; where great adhesion is desired, a large proportion of zinc should be used, and where a nice and durable polish is desired a greater per cent. of tin should be used.

An alloy of zinc, copper, and aluminum has been introduced as a dental base. (See also Carroll's alloys for cast dentures, Chapter XV.) It is said to be unaffected by the oral fluids.

Tin and aluminum form alloys little affected by acids. With 100 parts aluminum and 10 parts tin an alloy is produced much whiter than aluminum and but little heavier. It can be welded and soldered like brass.

Iron and aluminum unite readily. Ostberg, a Swedish inventor, discovered that an exceedingly small content of aluminum ($\frac{5}{1000}$ of 1 per cent.) in wrought iron served to lower its fusing point about 500° F., so that castings may be made from it as readily as from the highly carburized cast iron. Iron may be coated with aluminum much as it is with tin.

Zinc and aluminum unite to form alloys very useful for soldering the latter. They are prepared by first melting the aluminum and adding the zinc gradually, after which some fat is introduced to prevent oxidation, and the alloy is stirred rapidly with an iron rod. Aluminum may be frosted by immersion in a solution of potassa.

IRON.

Ferrum.	Symbol, Fe.
Atomic weight, 55.5.	Malleability, ninth rank.
Melting point, 1600° (2912° F.).	Tenacity, first rank.
Ductility, fourth rank.	Specific gravity, 7.844.
Conductivity (heat), 11.9.	Conductivity (electricity), 16.81.

(Silver being 100.)

Occurrence.—Iron is widely and abundantly distributed throughout nature, being found in nearly all forms of rock, clay, sand, and earth; its presence in these being commonly indicated by their colors, for iron is the commonest of all natural mineral coloring ingredients.

Properties.—Pure iron is a hard, malleable, ductile, and tenacious metal, of a grayish-white color, and of fibrous texture, slightly styptic taste, and has a sensible odor when rubbed. Its strength and tenacity are very high. In magnetic properties it is superior to all other substances, nickel and cobalt being next; when it is almost pure, the magnetic influence produced, owing to induction, by the proximity of a

permanent magnet or of an electric current, disappears entirely on removal of the magnet or current; if, on the other hand, carbon be present (as is usually the case to some small extent even in the softest malleable iron), there remains after the removal of the magnet or current a greater or less amount of permanent magnetism, according to the circumstances, hard steel exhibiting the greatest power of becoming permanently magnetized under given conditions. In thermic and electric conductivity iron is rated at 11.9 and 16.81, respectively. Its specific gravity is 7.844, its specific heat 0.1138, and its melting point is variously estimated from 1500° to 1600° C. (Pouillet) to 1900° to 2000° C. (Deville). The presence of minute quantities of carbon, sulphur, etc., very sensibly lowers the fusing point, while 1 per cent. of the former furnishes a steel melting at several hundred degrees lower than pure iron. Cast iron, containing more carbon, melts very much lower. It possesses the remarkable property of becoming plastic just before fusion, so that two hot masses may be pressed or squeezed together into one by the process of welding. So by forging, rolling, hammering, or other analogous operations, it can readily be fashioned into shapes which its rigidity and strength when cold will enable it to maintain.

Modifications of Iron.—There are three distinct modifications of iron, viz., cast iron, wrought iron and steel. Other intermediate varieties are recognized technically, but all are closely related and imperceptibly shaded into each other, due to various percentages of carbon, etc., contained in the metal.

Cast iron is an impure carburized iron. The melted metal drawn off from the furnace below is conducted into a large main, called the "sow," and thence into lateral molds called "pigs;" hence the term pig iron. This iron is found to have combined with a considerable quantity of carbon, about 4.5 per cent. being the maximum; a portion of which exists as a chemical combination, the carbide of iron, the remainder having been simply dissolved in the form of graphite. Other substances in the furnace are also found dissolved and combined in the iron, and have an important bearing upon its physical properties. These are principally phosphorus, silicon, sulphur, manganese, etc.

Pig iron may, therefore, be recognized as a crude form of cast iron. It is assorted and classed by the iron masters as Nos. 1, 2, and 3, differing in the amount of carbon contained. No. 1 is most highly carburized, No. 2 less, and No. 3 contains the least carbon. The first melts and becomes so fluid that it is used for ornamental castings of fine pattern, and furnishes cast-iron cutlery from which the carbon is subsequently extracted.

Cast iron, which contains the most carbon, is the most fusible variety, melting at about 1200° C. It is hard and brittle. Though some kinds admit of being made hard or soft nearly in the same manner as steel, and, like steel, assume different degrees of hardness, according to the rapidity with which the pieces are allowed to cool; but unlike steel, when once hardened, will not admit of that hardness being reduced by various gradations to any specific degree, called tempering. To

soften materially it must be submitted for some time to a whitish heat, and then very gradually cooled.

Wrought iron is the cast, or pig, iron, freed from carbon, and may be considered a nearly pure decarburized iron; at least, it is the purest form of commercial iron, containing the least amount of carbon—less than $\frac{1}{4}$ per cent. The decarburization is effected by first remelting the pig or cast iron, and refining by exposing it to an intense heat and forcing a blast of air over its surface, in order to remove some of the impurites of the metal; it is then run out into a large flat mold, and acquires the name of plate metal.

The next process is called "puddling," the object being to free the metal of its carbon. The operation is conducted in a reverberatory furnace, where the metal is again reheated and converted into wrought iron by keeping it in a state of fusion with a certain amount of black oxide of iron, Fe_3O_4, which gives up its oxygen after a time to the carbon, and other impurities of the melted mass, leaving the latter nearly pure iron. As the process approaches termination the fusing point of the mass grows higher, until it loses nearly all its fluidity. It is then divided into several parts and formed into balls, which are removed from the furnace and subjected to intense pressure through a series of powerful rollers, which squeeze out the more fusible slag entangled in it and convert it into bars or "bloom." A number of these blooms are then raised to a welding heat and repeatedly passed through rollers, until all the remaining slag is forced out and the metal becomes tough and fibrous. Thus the process is repeated usually once, and sometimes twice or three times, to produce a superior iron. By this process the metal is converted from a fusible, hard, and brittle substance, as cast iron, into a tough, elastic bar; in fact, it has been rendered malleable, ductile, more closely compact, and of a fibrous texture, and is less fusible. It is also very tenacious, and added to its properties is a new and remarkable one, by virtue of which two pieces being heated similarly may be forged or welded together. For purposes where lightness, strength, and durability are wanted, it is more extensively employed than cast iron. In this state it is known in commerce as bar, or wrought iron.

Steel is composed of iron and carbon, and, generally speaking, it is prepared by either one of two ways: by adding a certain percentage of carbon to a lightly carburized iron, such as wrought iron; or by abstracting an amount of carbon from a heavily carburized iron, such as cast iron. This fact gave rise to two typical methods of preparing steel, viz., the cementation process and the Bessemer process. While technically there are a variety of methods by which steel is made, yet all methods are more or less modifications of these two typical ones. The proportion of carbon varies, of course, in the different qualities of steel; but in that used ordinarily the carbon rarely exceeds $1\frac{1}{2}$ per cent.; for some purposes it is as low as 1 per cent. Good ordinary tool steel contains about $1\frac{1}{2}$ per cent. of carbon. Different kinds of iron produce steel of different properties, and different qualities of steel are used for different purposes.

Bessemer's Process.—By this process steel can be manufactured of any degree of hardness directly from the cast iron, without the intermediate operation of making it malleable by puddling, etc. The principle of the process consists in directing a blast of cold air upon molten cast iron contained in a "converter." The oxygen of the blast combines with the carbon, silicon, and manganese. Sulphur and phosphorus are difficult to remove by this process; hence the necessity of employing ores as free from these as possible. The intense combustion of the carbon in the iron is attended with great elevation of temperature, so that the metal is maintained in a fluid state throughout the whole operation, solely by the energy of the reaction in the converter. Thus the cast or pig iron is decarburized, or converted into tool steel, or to mild welding steel, or to the state of malleable iron, according to the length of time the combustion is continued. It has been found, however, that a better quality of steel can be produced by continuing the decarburizing and purifying process until all, or as nearly all as possible, of the carbon and impurities are removed, and then adding to the fused wrought iron a certain quantity of a peculiar kind of white cast iron known as spiegel-eisen[1] ("looking-glass" iron), containing a known quantity of carbon and a little manganesium and silicon.

Bessemer steel is largely used in the construction of railroads, bridges, armor plates for vessels, girders, etc., in the construction of edifices, the manufacture of machinery, tools, etc., and there is good reason to believe that steel of an excellent quality for numerous purposes will, at no distant period, be manufactured cheaper than wrought iron is now produced by the operation of puddling.

The Cementation Process.—The furnace in which the iron is cemented and converted into steel, called a converting furnace, has the form of a large oven, constructed so as to form in its interior two large and long cases, commonly called troughs or pots, and built of good fire-stone or fire-brick. Into each of these pots layers of the purest malleable iron bars and layers of pulverized charcoal are packed horizontally, one upon the other, to a proper height and quantity, according to the size of the pots, leaving room every way in them for the expansion of the metal when it becomes heated. After the packing is completed the tops are covered with a bed of sand or clay. This is to confine the carbon and exclude the atmosphere. The whole is then heated for eight or ten days, according to the degree of hardness required. Then the mass is left to cool for several days.

The properties of the iron are remarkably changed by this process: it acquires a small addition to its weight, becomes much more brittle and fusible than originally, loses much of its ductility and malleability, but gains in hardness, elasticity, and sonorousness. The texture, which was fibrous before, has now become granular; and its surface is found to be covered with blisters, and it presents, when broken, a

[1] Spiegel-eisen is composed of the following:

Iron	82.86
Manganesium	10.71
Silicon	1.00
Carbon	4.32

fracture much like inferior iron. Iron under this process has been shown to have taken up about 1 per cent. of carbon. It is, however, far from being homogeneous in composition, and is called blister steel. Uniformity of composition is secured by subjecting bundles of the carburized bars to repeated blows from a steam hammer at a welding heat, striking in rapid succession, until it closes the seams and removes the blisters. It is then termed shear steel. After this treatment is repeated it is called double-shear steel. Homogeneity is best obtained, however, by fusing the blister steel in crucibles, covering the mass with clay or some other substance to exclude air, and casting it into ingots. It is then designated as cast steel or crucible steel.

Spring steel is blister steel simply heated and rolled.

Case hardening is accomplished by heating such articles of forged or bar iron, as it is desired to harden superficially, in contact with some substance rich in carbon, and afterward chilling them in water. Gunlocks are thus treated.

Harveyized steel, which is employed for armor plate on account of its extremely hard and resistant surface, is prepared by heating the steel plate to the melting point of cast iron and then tightly packing its surface with carbon; after it has taken up about 1 per cent. of the carbon the plate is dropped into water and cooled.

Nickel Steel.—In 1889, M. Henry Schneider, of Creusot, France, patented an alloy of steel and nickel. The alloy usually contains about 5 per cent. of nickel, and is especially suitable for use in the construction of ordnance, armor plate, gun-barrels, and projectiles. It is said that ordinary steel is more readily acted upon by sea-water than are the more impure grades of iron, but nickel steel is less liable to corrode in salt water than ordinary steel.

Manganese Steel.—When about 15 per cent. of manganese is added to steel it produces an alloy of great strength and toughness, and so hard that it is almost impossible to work the product by ordinary methods. The alloy is usually prepared by adding manganese iron to molten Bessemer, or open-hearth steel. From 4 to 5 per cent. of manganese gives to the alloy its extreme brittleness. Extremes of atmosphere, heat or cold, do not appear to affect the properties of manganese steel. When a piece of it heated sufficiently to be seen red hot in a dark room is plunged into cold water, it becomes soft enough to be easily filed. Hardness is then restored by reheating to a bright red and cooling in air. The presence of manganese in proper proportions in nickel steel is said to very much improve it. Indeed, the best results are only obtained by the admixture.

Chrome Steel.—Chromium gives greater hardness, tensile strength, and elasticity to iron, but decreases its weldability. It is also stated that chromium steel is more susceptible of oxidation than ordinary steel. Chromium is added to iron by heating the mixed oxides of iron and chromium in a brasqued crucible with pulverized charcoal and fluxes. Chrome steel is then produced by melting chrome iron with wrought iron or steel in graphite crucibles.

Copper Steel.—This alloy usually contains from 5 to 20 per cent.

of copper, according to the purpose for which it is to be used. It possesses remarkable strength, tenacity, and malleability, and these properties are still further developed by tempering.

ALUMINUM STEEL.—In amounts not greater than 1 per cent. aluminum is said to slightly increase the tensile strength, and proportionally the elastic limit, of rolled and cast steel.

TUNGSTEN in small quantities produces an exceedingly hard steel, without the necessity of tempering.

CARBURIZED IRON.—As has been previously hinted, carbon may be present in iron under two conditions. When iron is fused in contact with carbon it is capable of combining with nearly 6 per cent. of the latter element to form a white, brilliant, and brittle compound, which may be represented pretty nearly as Fe_4C. Under certain circumstances, as this compound of iron and carbon cools, a portion of the carbon separates from the iron and remains disseminated throughout the mass in the form of minute crystalline particles very much resembling natural graphite.

Iron containing the least possible carbon, and otherwise comparatively pure, is called wrought iron.

Iron containing from 1.04 to 4.81 per cent. of carbon is designated as cast iron.

Iron containing from 0.15 to 1.04 per cent. (Bloxam) is considered steel. "The portion of combined carbon within certain limits bears a direct relation to the tensile strength of the metal, variations as minute as $\frac{1}{100}$ of 1 per cent. making a considerable alteration in this quality. The same is true of hardness, the effect of carbon up to a certain point being to increase tenacity and decrease ductility, and also to cause the metal, when heated and suddenly cooled, to become more or less hard, the hardening being in direct proportion to the amount of carbon present and the rate of cooling."[1]

1.4 per cent. of carbon in iron produces a highly carburized steel that must be worked with great care. It should not be heated above a cherry-red, for fear of burning. Such steel is used for the manufacture of razors and tools for cutting hard metals.

Steel containing from 1 to 1.25 per cent. of carbon is used for making most tools.

Steel containing about 1 per cent. of carbon can be welded readily, and a portion of a tool made of it can be made tough, so as to stand a blow from a hammer, without chipping, while another part can be hardened, as in the case of a cold-chisel.

HARDENING AND TEMPERING STEEL.—After soft steel has been shaped into the form of instrument desired, it may be made very hard by first heating to redness and then immediately chilling by plunging into cool water, oil, or mercury. If, however, the hardened steel be heated to redness again and allowed to cool slowly, it returns to its soft condition. Any desired variation between these two extremes may be obtained by heating the steel to redness and quickly chilling it, thus obtaining the full hard state. If this be polished and heated

[1] Kirk, American System of Dentistry, vol. iii. p. 900.

gradually and carefully, it will be found to take on a succession of shades and colors, owing to the formation of a film of oxide which grows thicker and of deeper shade and color as the heating progresses. The temperature at which given degrees of temper are produced has been carefully determined, and the experienced operator knows by the shade or color of the film of oxide the temper of the instrument operated upon, provided the piece is known to be steel and to have been full hard.

The following table shows the approximate temperatures corresponding to the various shades and colors:

Temperature.	Color.	Temper.
430° to 450° F.	Very faint yellow to pale straw.	Lancets, razors, surgical instruments, enamel chisels.
470°	Full yellow.	Excavators, very small cold-chisels.
490°	Brown.	Pluggers, scissors, pen-knives.
510°	Brown with purple spots.	Axes, plain irons, saws, cold-chisels.
530°	Purple.	Table knives, large shears.
550°	Bright blue.	Swords, watch-springs.
560°	Full blue.	Fine saws, augers.
600°	Dark blue.	Hand and pit saws.

Since the amount of hardness which can be developed in steel is directly in proportion to the amount of carbon and rate of cooling the article from the heated condition, and as pieces of steel vary greatly in their content of carbon, the temperature at which it is necessary to heat them before chilling must be determined by actual experiment, in order to produce the greatest hardness. The piece should never be overheated. It is better to err upon the side of underheating instead of overheating, for under the latter condition the steel is burned, presents a blistered, scaly appearance, and is incapable of taking a fine tempr. When small instruments, such as burs, excavators, etc., are to be hardened, it is best to protect the surface of the steel with some substance to prevent a loss of carbon by oxidation in the heating. "Common soap answers admirably for this purpose," says Dr. Kirk.

The means of applying the heat to articles when they require hardening will, of course, depend upon the size, shape, and use of the article. They may be heated in the flame of the Bunsen burner, alcohol lamp, open fire, and sometimes it is best to enclose them in a sheet-iron case with carbon, and heat in a suitable furnace; but for a more uniform degree of heat red-hot lead is probably better than any other means.

In chilling, water is by no means essential, as the sole object is to extract the heat as rapidly as possible by good conduction; and the more suddenly the heat is extracted, the harder the steel will be; but if the hardness is not carried to an extreme, a certain amount of tenacity is also obtained with the hardness.

Water with a small amount of acid or salt is sometimes used, the former to aid in removing the oxide, and the latter to increase the conductivity. For extreme hardness mercury is used, which, on account of its superior conductivity, chills the piece immediately.

Tempering.—A rod of good steel in its hardest state is broken almost as easily as a rod of glass of the same dimensions. This brittleness can only be diminished by decreasing its hardness; and the management of this is called tempering. The surface of the steel is brightened and tried with a fine file to make sure of its full-hardness, and is then exposed to the heat, which, upon the appearance of the color desired and previously determined upon, is discontinued, and the article cooled by instantly plunging into cool water. The methods for applying the heat for tempering are as varied as those for hardening. The heat for this purpose should be slowly applied; indeed, it is said that the slower the heating, the tougher and stronger will be the steel. The article may be placed upon a hot iron plate, upon the surface of melted lead, or in a bath of a more fusible alloy; in hot sand, a gas stove, or in almost any place where sufficient temperature may be gradually obtained, without injury to the steel.

The following table of alloys of lead and tin may be conveniently used to secure a uniform temper:

Composition.		
Lead.	Tin.	Melting points. Degrees F.
7.0	4	420°
7.5	4	430°
8.5	4	450°
10.0	4	470°
14.0	4	490°
19.0	4	510°
30.0	4	530°
48.0	4	550°
50.0	4	560°
Boiling oil		600°

(Compare the degrees with the colors of the previous table.)

When instruments are only partially dipped and afterward tempered by the heat from the back, they must be cooled in water, or other substance, instantly on the cutting part attaining the desired color; otherwise the body of the instrument will continue to supply heat, and the cutting part may become too soft. In the case of excavators, enamel chisels, and cutting instruments with slender, tapering shanks, terminating in a fine cutting edge, the edge must be protected from the heat while tempering the shank, the latter being drawn to a blue, a state much too soft for the former. The point or edge may be protected by placing against a large piece of cold iron or other subtance which, on account of its conduction, prevents the heating of the end of the instrument.

Rubber-dam clamps are best tempered a blue spring by what is known as blazing off. This is accomplished by dipping them in oil, and then burning the oil off.

Action of Acids on Iron.—Iron dissolves in the acids, and the carbon which it almays contains, so far as combined in the carbide of iron, passes off as carburetted hydrogen, and so far as uncombined will remain undissolved, as graphite.

COPPER.

Cuprum.	Symbol, Cu.
Atomic weight, 63.1.	Malleability, third rank.
Melting point, 1200° (2192° F.).	Tenacity, second rank.
Ductility, fifth rank.	Specific gravity, 8.94.
Conductivity (heat), 73.6.	Conductivity (electricity), 99.95.

(Silver being 100.)

Occurrence.—This exceedingly interesting and useful metal has been known and used by the human race since the most remote periods. Its alloy of tin-bronze was the first metallic compound used by man. It is found in the metallic state in the Lake Superior region, and in Virginia, the southwestern portion of the United States, and many other parts of the world.

Properties.—Copper, or cuprum, in name is derived from *Kupros*, the Greek spelling of Cyprus, an island where it is extensively mined. Its symbol is the planet Venus, as the isle of Cyprus was sacred to that goddess. It is a peculiar red-colored, brilliant metal, differing in this respect from all other metallic elements, except, perhaps, titanium. Its atomic weight is 63.1, and its specific gravity 8.94. It takes a brilliant polish, and is very malleable and ductile, being second to iron in point of tenacity. It may be rolled into thin sheets or drawn into very fine wire. A copper wire, hard drawn, having a sectional area of a square millimetre, sustained a weight of 90.20 pounds at the moment of rupture. The same wire, annealed, broke under a weight of 69.52 pounds.[1] The melting point of copper is probably best stated at 1200° C. or 2192° F., and it expands slightly on passing from the molten to the solid state. It is unaffected by dry air, but in a moist atmosphere it becomes coated with a green carbonate, malachite, which is also found native in most beautiful shades, takes a high polish, and is used for ornamental articles. When heated or rubbed with much friction, it emits a peculiar, disagreeable odor. In the conductivity of heat (73.6) and electricity (99.95) it is second only to silver (100).

Copper does not dissolve in acids with evolution of hydrogen.

In nitric acid it dissolves most readily, chiefly with the evolution of nitric oxide, forming copper nitrate.

In sulphuric acid, hot and concentrated, it also dissolves readily, with evolution of sulphurous anhydride, forming copper sulphate—blue vitriol.

In hydrochloric acid copper is slowly soluble.

Alloys.—The preparation of copper alloys is generally attended with many difficulties, on account of the high fusing point of the metal and the almost invariable presence of small quantities of other elements.

Gold and copper alloy readily, the latter giving a desirable hardness to gold and deepening its color. If, however, any considerable portion of copper be added to gold, the alloy is apt to be brittle, especially if the copper be not absolutely pure. For United States gold coins 10

[1] Ganot, Elements de Physique.

per cent. of copper is added to pure gold, giving it a carat fineness of 21.6 and a proper degree of hardness for durability.

Silver and copper also alloy readily, and the copper again gives hardness with a slight change of color. Ten per cent. of copper is added to silver for United States coin.

Platinum and copper alloy at an intense white heat, giving an alloy much resembling gold in color and specific gravity.

Lead added to copper from $\frac{1}{1000}$ to $\frac{3}{1000}$ somewhat increases its ductility and malleability, but the presence of $\frac{1}{1000}$ renders the metal unfit for preparation of malleable or ductile brass.

Iron to the amount of $\frac{3}{1000}$ also has an injurious effect upon the properties of copper, rendering it hard and brittle.

Antimony, bismuth, and arsenic in small quantities have a very injurious effect upon copper.

Babbitt metal consists of copper 4, tin 12, and antimony 8, melted separately. The antimony is added to the tin, then the copper, and 12 parts more tin after fusion.

TYPE METAL—TABLE OF COMPOSITION.[1]

Metal.	Parts.				
	I.	II.	III.	IV.	V.
Lead	3	10	70	6	100
Antimony	1	2	18	..	30
Copper	..	..	2	4	8
Bismuth	..	1	..	..	2
Zinc	..	..	..	90	
Tin	..	..	10	..	20
Nickel	..	..	..	..	8

Britannia Metal (Wagner's) consists of tin 85.64, antimony 9.66, copper 0.81, zinc 3.06, and bismuth 0.83.

Queen's Metal consists of tin 88.5, antimony 7.1, copper 3.5, and zinc 0.9.

Zinc alloys with copper in any proportion, all of which alloys are included in the term brass. Alloys of copper and zinc were known in the time of Aristotle, and the manufacture of brass was first introduced in Germany in 1550, but was probably not produced by the direct union of the two metals until 1781 in England, as the art of obtaining zinc in the metallic form became known but a short time previous to that period. Notwithstanding copper and zinc may be alloyed in any proportion, the product is always serviceable. "Generally speaking, it may be said that with an increase in the percentage of copper the color inclines more toward a golden, the malleability and softness of the alloy increasing at the same time. With an increase in the percentage of zinc, the color becomes lighter and lighter, and finally shades into a grayish-white, while the alloy becomes more fusible and brittle and at the same time harder."[2] Alloys containing from 15 to 20 per cent. zinc are the most ductile. Those of 36 to 40 of zinc can be worked cold as well as hot, while those containing 60 to 70 of zinc are so brittle that they cannot be worked at all. Raising this percentage to from 70

[1] Table from Brannt.

[2] Brannt, Metallic Alloys.

to 90 of zinc, the alloy again becomes ductile, and can be worked quite well when hot, but not when cold. An alloy of copper 75 and zinc 25 fuses at 1750° F.

Good sheet brass may be made according to many formulæ; two are cited:

> Rosthorn (Vienna)—Copper 68.1 and zinc 31.9 parts.
> Romilly—Copper 70.1, zinc 29.26, lead 0.38, and tin 0.17 parts.

For wire, the following:

> England—Copper 70.29, zinc 29.26, lead 0.28, and tin 0.17 parts.
> Neustadt—Copper 71.5 and zinc 28.5 parts.[1]

Alloys containing as high as 37 per cent. of zinc are used as ductile and malleable products.

Fine cast brass usually contains from 20 to 50 parts of zinc to 100 parts copper, together with lead, or tin, or both in the proportion of 0.25 to 3 per cent. of each.[2]

Oreide (French gold) is a brass alloy much resembling gold. It takes a fine polish and is very ductile, malleable, and much used for the manufacture of cheap jewelry, on account of its beautiful color. Formula by analysis.—copper 68.21, zinc 13.52, tin 0.48, and iron 0.24.[3]

"The most malleable of the brasses is Dutch metal, composed of copper 11, zinc 2 parts; it can be rolled out into thin sheets and afterward beaten into leaves of extreme tenuity, and is used in this form for decorative purposes under the name of Dutch leaf-gold or, reduced to powder by levigation with a small quantity of oil or honey, it is sold as bronze powder."[4]

Pinchbeck, an alloy of copper 88.8 and zinc 11.2 parts, very much resembles gold; is very ductile and malleable; used for cheap jewelry.

Mosaic gold, a term sometimes applied to tin sulphide, is composed of about equal parts of copper and zinc.

Copper Coins.—Those of the United States are composed of copper 95, tin 3, zinc 2 parts.

Nickel and copper unite in all proportions, the color varying from the red of copper to the blue-white of nickel, according to the proportions of the respective metals:

Copper with 10 per cent. of nickel gives a light copper-colored alloy, very ductile; with 15, the color is a very pale red, but the alloy is still quite ductile; with 25, a nearly white alloy, and 30, a silver-white alloy. United States nickel coins are composed of copper 75 and nickel 25 parts.

Nickel, copper, and zinc alloys are called German silver, argentan, etc. They are in reality brasses with nickel added, which gives them a white color and much hardness.

[1] Figures from Brannt, Metallic Alloys.
[2] Ibid. [3] Ibid.
[4] Kirk, American System of Dentistry.

These compositions vary greatly, as may be noticed:

Copper	50 to 66 parts.
Zinc	19 " 30 "
Nickel	13 " 18 "[1]

White Metal.—A variety of alloys consisting of copper and a large proportion of zinc. They are very white, or, depending upon the proportion of copper, may be a pale yellow; melt at a low point, may be cast, and are somewhat malleable and ductile.

Aluminum alloys easily with copper, producing aluminum bronze, the alloys showing different properties, according to the quantity of aluminum they may contain. With 60 to 70 per cent. aluminum, a very brittle alloy is produced; with 50 per cent., one quite soft, but less than 30 per cent. of aluminum, the hardness returns. The bronze composed of copper 95, aluminum 5, is a beautiful gold color, takes a fine polish, casts well, is malleable hot or cold, and is very strong, especially after hammering. With 7.5 per cent. aluminum, the color is a greenish golden. The most common alloy is 10 per cent. aluminum, which yields a bright golden, is not tarnished in air, may be engraved, possesses, it is said, greater elasticity than steel, and may be soldered with 20-carat gold solder. It melts at about 1700° F.

Tin and copper form a very important series of alloys termed bronze. (See Tin.)

Brazier's Solder.—An alloy composed of copper, zinc, tin, and lead in a variety of proportions, according to color and fusibility.

Dr. Kirk gives the following table:

	Copper.	Zinc.	Tin.	Lead.
A. Golden yellow	53.50	43.34	2.12	
B. Medium light	43.75	50.58	3.75	1
C. White	57.50	27.90	14.90	trace

It is used in soldering brass and copper, which may also be soldered with the ordinary soft solder, spelter (zinc), or silver solder.

Copper is a constituent of most hard solders, its proportion varying according to the purpose for which they are to be used. (See Silver and Gold.)

ZINC.

Zincum.	Symbol, Zn.
Atomic weight, 64.9.	Malleability, eighth rank
Melting point, 415° (779° F.).	Tenacity, sixth rank.
Ductility, sixth rank.	Specific gravity, 6.915.
Conductivity (heat).	Conductivity (electricity).

(Silver being 100).

[1] Brannt, Metallic Alloys.

Occurrence.—Zinc is a somewhat abundant metal, but never occurs in the native state. It is found as a carbonate, sulphide, silicate, etc., associated with lead ores in many districts; large supplies are obtained from Silesia and from the neighborhood of Aachen.

Properties.—Zinc is a bluish-white metal, which but slowly tarnishes in moist air, usually forming a superficial carbonate; it has a specific gravity of 6.915, and is, under ordinary circumstances, quite brittle, but when heated to 100° or 150° C. it may be rolled or hammered into thin sheets, or drawn into wire; and, what is very remarkable after such treatment, it retains its malleability when cold; the sheet zinc of commerce is thus made. If the temperature be carried to 205° C. it again becomes so brittle that it may be easily powdered in a mortar. Care should be exercised in handling hot zinc dies, for if by accident one be dropped upon a hard surface it is likely to be ruined. The metal melts at 415° C. or 779° F. It boils and volatilizes at 1040° C. or 1904° F., and, if air be admitted, burns with a splendid greenish incandescence, forming the oxide. In boiling water zinc is said to be attacked appreciably, forming the hydroxide, Zn2HO, with evolution of hydrogen.

Zinc has long been very extensively used in the dental laboratory for making dies. Its comparatively low fusibility, hardness, and other properties eminently fit it for this purpose.

Pure zinc dissolves very slowly in acids (or alkalis), unless in contact with copper, platinum, or some less positive metal. Any metallic impurity in zinc renders it quite soluble in the acids or alkalis.

Alloys.—Zinc readily unites with gold. The malleability, brilliancy, and color of gold are impaired by a content of zinc.

Small pieces of platinum may be dissolved in molten zinc, and the union is attended with considerable energy, owing to the formation of a definite chemical compound. The alloy is hard and brittle. An alloy may be prepared of platinum, 16; copper, 7; and zinc, 1; which very much resembles gold in color, specific gravity, and ductility.

Silver and zinc have a great affinity for each other. This fact, with the knowledge that zinc and lead are comparatively so incompatible, led to the process of desilvering lead by the assistance of zinc. The alloy of silver and zinc is best obtained by throwing the required quantity of zinc wrapped in paper into molten silver, stirring thoroughly with an iron rod, and pouring the fused mass at once. The alloy of two parts zinc and one part silver is flexible, ductile, and has nearly the color of pure silver. Larger proportions of zinc produce brittle alloys.

Iron plate and ware when perfectly cleaned may be immersed in molten zinc and the surface alloyed slightly, forming what is known as "galvanized iron," the name being derived from the circumstance that the coating is analogous to that produced by electric means. Zinc alloys with the iron melting pots of the laboratory, the admixture rendering the zinc less fluid when molten and more difficult to fuse. This contamination may be prevented by coating the pot with whiting.

With lead zinc does not alloy, except to a very slight degree. "Mat-

thiessen found[1] that on melting equal parts of zinc and lead, and, after well mixing, allowing the alloy to cool slowly, they separate, but the heavier lead on subsiding retains 1.6 per cent. of the zinc alloyed with it; while on the other hand the upper layer of zinc thrown out retains 1.2 per cent. of lead."

It often occurs that lead and zinc will become mixed in the laboratory, and is seldom discovered until the molten mixture is poured. Then the lead, owing to its greater specific gravity, falls to the bottom of the mold, forming the alveolar ridge of the die, rendering it worthless. Many times the counter-die is poured before the mistake is noticed, resulting in a union of the die and counter-die.

Tin and zinc alloy in almost any proportion. Mr. Fletcher recommends an alloy of zinc 2 parts and tin 1 part for making dies for swaging, claiming the impression from the sand is much finer, and the shrinkage on cooling is greatly reduced. It melts much lower than zinc alone, hence some care must be exercised in pouring the counter-die. The die should be perfectly cold and the lead should be just hot enough to pour, but not sufficiently heated to char a slip of paper.

BISMUTH.

Symbol, Bi.

Atomic weight, 206.9.	Malleability, brittle.
Melting point, 264° (507° F.)	Tenacity, brittle.
Ductility, brittle.	Specific gravity 9.823.
Conductivity (heat), 1.8.	Conductivity (electricity), 1.24.

(Silver being 100.)

Occurrence.—Practically the only ore of this element is the native metal found disseminated in veins through slate rock associated with the ores of copper, iron, cobalt, nickel, silver, gold, and arsenic.

Properties.—Bismuth is a highly crystalline, hard, and very brittle metal, having a grayish-white color, with a decided reddish tint. Its specific gravity is 9.823, and it fuses at 264° (507.2° F.). It expands about $\frac{1}{32}$ of its volume upon cooling, and imparts this property to its alloys. The metal volatilizes at a high temperature, and has a specific heat of 0.0308. It is the most diamagnetic of all substances. Exposed to the air at ordinary temperatures, it is unaffected, but when heated to a red heat it rapidly oxidizes, producing a beautiful play of colors.

Sulphuric and hydrochloric acids have but slight action on bismuth, while nitric acid dissolves it very energetically.

Alloys.—Bismuth has its greatest use in the preparation of low fusing alloys.

With tin bismuth alloys in any proportion. A very small quantity of the metal imparts to tin more hardness, sonorousness, lustre, and a fusibility lower than either of the metals taken separately possesses. An alloy of equal parts of the two metals fuses at 212° C.

[1] Makins' Metallurgy, p. 62.

With lead bismuth alloys very easily, producing an alloy which is malleable if the proportion of bismuth does not exceed that of lead. The specific gravity is greater than the mean of the two taken separately. Its alloys are white, lustrous, harder than lead, and more malleable up to a certain proportion. Bismuth 1 and lead 2 gives a very ductile and malleable alloy fusing at 330° F.

With antimony it produces a grayish, brittle, lamellar alloy. Lead and tin added render it malleable, but its fusibility is increased rather than decreased. Such alloys are very frequent and much used in the preparation of Britannia and Queen's metal.

	Bi.	Sb.	Sn.	Pb.
Cliché-metal	9.0	10.5	48.0	32.5
		Type-metal.		
"	8.0	1.0	4.0	5.0
"	1.0	3.0	..	8.0

Alloys of bismuth, tin, and lead are known as the triple alloys, and are very numerous and useful.

Newton's alloy, sometimes called "Melotte's metal," consists of bismuth 8, lead 5, and tin 3 parts, and fuses at 202° F.

Rose's fusible alloy is composed of

	I.	II.
Bismuth	2	8 parts.
Tin	1	3 "
Lead	1	8 "

The first fuses at 200.75° F. and the second at 174.2° F.[1] They were used as safety plates and inserted in the top of steam boilers, intended to prevent the explosion of boilers by allowing the steam to escape at a certain tension.

Wood's metal consists of lead 4, tin 2, bismuth 5 to 8 and cadmium 1 to 2, melts at 140° to 161.5° F., in color resembles platinum, and is, to a certain extent, malleable.[2]

Onion's fusible alloy contains lead 3, tin 2, and bismuth 5 parts, and melts at 197° F.

La Nation describes a new fusible alloy, of which the following is the formula: Bismuth 48, cadmium 13, lead 19, and tin 26. It melts at 158° C. and resists great pressure.

Hodgen's fusible, alloy, for making dies and counter-dies by the dipping process, is composed of the following: Bismuth 8, lead 5, tin 3, and antimony 2. It is a light, lustrous alloy, very hard, slightly malleable, expands slightly on cooling, copying the finest of lines, takes a high polish, and resists great pressure, melting at 224° F.

Dr. Mathews' Fusible Alloy.—This alloy is composed of bismuth 48, cadmium 13, and tin 19 parts. It melts below the boiling point of water and may be packed with the fingers. It may be poured into plaster impressions immediately after they have been taken, producing

[1] William T. Brannt. [2] Ibid.

sharp, bright, hard dies, with which shot may be used for the counter-die.

Darcet's fusible alloys are a series of proportions of bismuth, tin, and lead, and their melting point varies as per the following table:

Parts.			Melts.
Bismuth.	Tin.	Lead.	
7	4	2	212° F.
16	7	4	212° F.
8	2	6	205° F.

Most of these fusible alloys are of much value in the dental laboratory in the hands of a practical, resourceful man. The cleaner ones may when lack of time will not permit of a more perfect repair, be used to mend a denture or replace a tooth or block of teeth on a vulcanite plate, and the more fusible ones may be used for the same purpose, even though the base be celluloid. In replacing teeth undercuts may be made with a file, or preferably with a large bur in the engine, the tooth placed in position, and the alloy packed in with warm instruments, smoothed, and afterward polished. These alloys are also valuable baths for tempering steel instruments. They give a very exact temperature, which may be adjusted to the purpose intended. They are used, according to Thurston, by placing the articles on the surface of the unmelted alloy and gradually heating until fusion occurs and they fall below the surface, at which moment their temperature is right; they are quickly removed and cooled in water.

TIN.

Stannum.	Symbol, Sn.
Atomic weight, 118.1	Malleability, fourth rank.
Melting point, 228° (442° F.).	Tenacity, seventh rank.
Ductility, seventh rank.	Specific gravity, 7.29.
Conductivity (heat) 14.5.	Conductivity (electricity), 12.36.

(Silver being 100.)

Occurrence.—Tin occurs chiefly as tinstone, cassiterite, or native oxide, SnO_2. The pure ore is colorless and very scarce. Another native form known as "wood tin" occurs in roundish masses. The metal is rarely, if ever, found free.

Properties.—Pure tin is white (except for a slight tinge of blue); it exhibits considerable lustre, and is not subject to tarnishing on exposure to normal air. It is soft and exceedingly malleable; indeed, it is said it may be beaten into foil $\frac{1}{40}$ of a mm. in thickness; at 100° C. it may be drawn into wire, but is almost devoid of tenacity. That it is elastic, within narrow limits, is proven by its clear ring when struck with a hard body under circumstances permitting free vibration. Though it is seemingly amorphous it has a crystalline structure, hence the crackling noise known as the "tin cry" which a bar of tin emits on being bent. The crystalline structure must also account for the

strange fact that an ingot, when exposed to the temperature of −39° C. for a sufficient length of time, becomes so brittle that it falls into powder under pestle or hammer. At some temperature near its fusing point it again becomes brittle. Tin fuses at 228° (442.4° F.).[1] At a red heat it begins to volatilize slowly; at 1600° to 1808° C. it boils[2] and may be distilled. The hot vapor produced combines with the oxygen of the air, forming the white oxide, SnO_2. The specific gravity is 7.29. Its specific heat is 0.0562.

Casts of tin are used to vulcanize upon, and plaster casts are often covered with tin-foil to give a clear and finished appearance to the denture after the process of vulcanization.

Tin dioxide under the name of "polishing putty" is used for polishing glass, ground porcelain surfaces, hard metals, and similar substances.

The three mineral acids and boiling solutions of the caustic alkalis act on tin.

Alloys.—Gold and tin form a malleable alloy, provided the tin be pure and does not exceed in quantity 10 per cent.

Platinum and tin in equal proportions form a hard, but brittle, alloy, fusing at a comparatively low temperature.

Palladium, says Mr. Makins, forms a very brittle alloy with tin.

In view of the fact that gold, platinum, and palladium so readily unite with tin to form alloys whose fusing points are so comparatively low, and in view of the behavior of tin with other metals, and of metals in general toward each other, there is little reason to doubt a chemical affinity of tin for these metals. The affinity of tin for gold in particular has been clearly demonstrated by Dr. Matthiessen. Into a crucible of molten tin a rod of gold and one of copper were dipped, the latter having been previously tinned to ensure perfect contact. The gold united readily and rapidly with the tin, while the copper rod remained unaffected. A gold wire which has been superficially tinned will melt like one of tin when held in the flame of a Bunsen burner. A wire of tinned copper exposed to the same heat, under like circumstances, remains unaffected, except that the tin is burned off. The affinity of tin for platinum is so great, states Clarke, that if tin and platinum foils be rolled together and heated before the blowpipe, combination takes place explosively. The affinity of tin for gold is unquestionably an interesting subject for the dentist, in view of the place these two metals occupy in operative dentistry.

Silver alloys with tin, and, in the proportion of 80 of the former to 20 of the latter, it is said produces a very tough alloy.

Dr. G. F. Reese's alloy for artificial dentures, constructed by the cheoplastic process, is composed of tin 20, gold 1, and silver 2 parts. Other alloys much used in cheoplastic work are composed largely of tin.

Bean's alloy, intended for casting lower dentures, is composed of tin 95 and silver 5 parts.

Antimony 1 and tin 16 parts form another alloy, which is intended

[1] Rudberg. [2] Williams.

for the same purpose, and was introduced by the late Dr. William B. Kingsbury.

Britannia metal is made under a great variety of formulæ; one known as English is composed of antimony 7.8, tin 90.7, and copper 1.5. It sometimes contains lead or bismuth.

Tin is easily deposited upon small articles of brass or copper by simple immersion, as by the following experiment:

Place the articles in layers between sheets of grain tin in a saturated solution of potassium bitartrate and boil. A little stannous chloride may also be added, if necessary.

LEAD.

Plumbum.	Symbol, Pb.
Atomic weight, 205.35.	Malleability, seventh rank.
Melting point, 325° (617° F.)	Tenacity, lowest (eighth) rank.
Ductility, eighth rank.	Specific gravity, 11.25.
Conductivity (heat), 8.5.	Conductivity (electricity), 8.32.

(Silver being 100.)

Occurrence.—This abundant and very useful metal is almost wholly obtained from its native sulphide (PbS), or galena, and is rarely, if ever, found free.

When found associated with silver, the ore is termed argentiferous galena.

Properties.—Pure lead is a feebly lustrous, bluish-white metal, endowed with a high degree of softness and plasticity, and almost entirely devoid of elasticity. A wire $\frac{1}{10}$ of an inch in thickness is ruptured by a weight of about thirty pounds. It is said to be the least tenacious of all metals in common use. Its specific gravity is about 11.25. It melts at 325° C. or 617° F. At a bright-red heat it vaporizes and at a white heat boils. Its specific heat is 0.0314. Lead exposed to ordinary air is rapidly tarnished, forming it is supposed a suboxide. The same supposed suboxide is formed upon lead kept in a state of fusion in the presence of air, when at the same time the metal rapidly absorbs oxygen; then the monoxide (PbO) is formed, the rate of oxidation increasing with the temperature. Its chief use in dentistry is in the laboratory as a counter die.

Action of Acids on Lead.—The presence of carbonic acid in a water does not affect its action on lead. Aqueous non-oxidizing acids generally have little or no action on lead in the absence of air.

Sulphuric acid, when dilute (20 per cent. solution or less), has no action on lead, even when air is present, nor upon boiling. Stronger acid does act slowly, in general, but appreciably, the more so the greater its concentration and the higher its temperature. Pure lead is more readily acted upon than that contaminated with antimony or copper. Boiling concentrated sulphuric acid converts lead into the sulphate, with evolution of sulphurous oxide.

The metal is readily dissolved in dilute nitric acid, nitrogen dioxide being evolved and plumbic nitrate formed.

Strong and hot hydrochloric acts but slowly upon lead, forming the dichloride and liberating hydrogen.

Water when pure, has no action on lead per se. In the presence of free oxygen (air), however, the lead is quickly attacked, forming a hydrated oxide, $Pb2HO=PbOH_2O$, which is appreciably soluble in water, rendering the liquid alkaline. When carbonic acid is present the dissolved oxide is soon precipitated as basic carbonate—$PbCO_3$ (which is slightly soluble in water containing carbon dioxide)—so there is room made, so to say, for fresh hydrated oxide, and the corrosion of lead progresses. Now, all soluble lead compounds are strongly cumulative poisons, hence the danger involved in using lead pipes or cisterns in the distribution of pure waters. We emphasize the word "pure," because experience shows that the presence in water of even small proportions of bicarbonate or sulphate of lime prevents its action on lead. This little sulphate, almost invariably present, causes the deposition of a very thin but closely adherent film of lead sulphate upon the surface of the metal, which protects it from further action.

Alloys.—Pure lead unites with almost all metals. Very small quantities of lead admixed with the noble metals destroy completely their malleability, and hence render them unworkable. It is said that $\frac{1}{1920}$ part of lead in gold will greatly impair its coining property, and that gold containing $\frac{1}{500}$ part of lead is "rendered unfit for coinage." The gold drawer in the dental laboratory is often so situated that it is almost impossible to prevent particles of lead from accumulating with the gold scraps and filings. These, however, may be easily removed by roasting with potassium nitrate and sulphur.[1]

Tin unites with lead in almost any proportion with slight expansion.[2]

The following table gives an idea of the melting points of alloys of lead and tin:

An alloy of—	Fuses at—
Lead 1, Tin 2	340° F.
" 1, " 6	382° F.
" 2, " 1	442° F.
" 4, " 1	498° F.
" 17, " 1	557° F

With tin 1 part and lead 5 parts[3] Dr. Haskell makes counter-dies to be used with Babbitt-metal dies. It fuses at a lower temperature than the die alloy, and also has the advantage of being harder than lead, which he claims is too soft for counter-dies.

Tin-lead alloys are used largely in soldering. The following are compositions and melting points of frequently used compounds:[4]

Grade.	Tin.	Lead.	Melts at—
Fine solder	2	1	340° F.
Common "	1	1	370° F.
Coarse "	1	2	442° F.

[1] See Gold.

[2] Kuppfer.

[3] The author has found the fusing point of this alloy to be 378° F.

[4] Tomlinson.

Pewter may be said to be substantially an alloy of the same two metals; but small quantities of copper, antimony, and zinc are frequently added. Common pewter contains about 5 parts of tin for 1 of lead. In France a tin-lead alloy, containing not over 18 per cent. of lead, is recognized by law as being fit for measures for wine or vinegar. "Best pewter" is simply tin alloyed with a mere trifle ($\frac{1}{2}$ per cent. or less) of copper.

Lead contaminated with small proportions of antimony is more highly proof against vitriol than the pure metal. An alloy of 83 parts of lead and 17 parts of antimony is used as type metal; other proportions are used, however, and other metals added besides antimony—*e. g.*, tin, bismuth—to give the alloy certain properties.

Arsenic renders lead harder. An alloy made by the addition of about $\frac{1}{56}$ of arsenic is used for making shot.

Lead forms a very important part in "fusible alloys."[1]

[1] See Bismuth.

CHAPTER III

PORCELAIN TEETH.

By Charles J. Essig, M.D., D.D.S.

Revised by Ellison Hillyer, D.D.S.

The general use of porcelain teeth in dentistry began about 1825. Previous to that date the materials and means employed in the construction of artificial dentures were confined to the various methods of setting human teeth, the teeth of animals, and carving dentures of hippopotamus tusks, walrus, and elephant ivory, etc. The part of the human tooth used by the dentists, except in transplantation, was the crown portion.

MATERIALS USED IN THE FORMATION OF BODIES AND ENAMELS.

These are feldspar, silica, and kaolin or clay. The pigments employed to imitate the various shades of color of the natural enamel, dentin, and gums are titanium oxide, platinum, cobalt, iron, gold, and tin.

The Body.—The body represents the dentin of the natural tooth, and is composed of feldspar, silica (in the form of finely ground quartz), and kaolin (clay), and the yellow-white or ivory-like color of that portion of a tooth is imparted to it by the addition of finely ground titanium oxide.

The Frits.—A frit is an imperfectly vitrified mass, formed by the partial fusion of sand and fluxes, from which glass is made by melting. The frits which enter into the composition of teeth are crude colors composed of metallic oxides, such as those of gold, tin, cobalt, etc., ground exceedingly fine, in combination with feldspar and certain fluxes, which will hereafter be described. These are burned in a suitable crucible, and then powdered for use in imparting tints to enamels.

Enamels.—Enamels are composed chiefly of feldspar, to which is added sufficient quantities of the different frits to produce as nearly as possible the colors of the natural teeth and gums.

Bodies and enamels especially prepared for the manufacture of porcelain teeth should possess, after burning, translucency and natural color, together with strength and heat-conducting qualities to a degree that will admit of soldering without danger of fracture from unequal expansion. Translucency and the power of withstanding high temperature in soldering depend largely on the feldspar, which forms four-fifths of the bulk of the body.

Silica is next in importance as a constituent of the body: its function is to add density and the strength required for masticatory purposes, and, being highly infusible, to assist in retaining the teeth in shape during the burning process. Without silica the teeth when near the fusing

point would evince a tendency to assume the spherical form, and their lines and characteristic features would be lost.

Kaolin, according to S. Welles Williams, "Middle Kingdom," obtained its name from Kao Ling, a place in China where it was first obtained. The name has been adopted for all varieties of feldspathic components of porcelain. Kaolin and the clays in general give plasticity to the body, by which the workman is enabled to mold and handle the unburned teeth and blocks without danger of breaking them; it also imparts strength to the porcelain mixture.

Feldspar.—This is generally spoken of as a double silicate of aluminum and potassium, and is represented by the formula $Al_2O_3.K_2O,.6SiO_2$. The best quality of feldspar is found in the neighborhood of Wilmington, Del. It possesses a distinct cleavage, and when broken splits into plates of more or less magnitude. It is of an indefinite color, between yellow and pink, but when fused in the furnace it becomes transparent and colorless, and if not exposed to a too prolonged or an excessively high temperature it retains its original form without rounding at the corners: this is one of the tests of good feldspar.

Feldspar from different parts of the same quarry has been observed to differ in quality. In selecting spar for the preparations of enamel a number of pieces broken from the most perfect-appearing specimens should be fused in the furnace to determine the quality. The crude pieces from which the samples were taken, if found satisfactory, are then broken into small fragments with a steel hammer until they become of a size to admit of its being ground in a large Wedgwood mortar; at intervals the powder is sifted through a No. 10 bolting-cloth sieve, placed in covered jars, and kept dry for future use.

In the preparation of feldspar for enamels the grinding should not be carried too far, as transparency may be greatly lessened, or even entirely lost, by its being ground too fine. The effect of a complete obliteration of the crystallization of the feldspar by too much grinding may be observed in a test suggested by Dr. William R. Hall in the chapter on "Moulding and Carving Porcelain Teeth," *American System of Dentistry:* It consists in placing on a slide covered with coarse silex a small piece of crude feldspar of the best quality; then taking another piece from the same specimen, grinding it very fine, and fusing the two in the furnace; when cold the difference in appearance will demonstrate that when ground into a very fine powder loss of transparency is apparent, and that to preserve its beauty feldspar must be ground only to a certain fineness, beyond which opacity is the result.

In preparing feldspar in large quantities for extensive use by the manufacturers of molded teeth it is customary to calcine the spar by heating to redness and dropping it into water while hot. This is done to facilitate the reduction of the large masses into small fragments suitable for grinding in the mortar, which in the large factories consists of a tub with a burr-stone or quartz bottom. The pestle, which is generally formed of a piece of the same mineral, is arranged to revolve by machinery. The grinding is done under water. While this plan is less laborious than dry grinding, it probably never affords as good results, in consequence of the excessive fineness of the powdered spar.

Silica (SiO_2).—This body, sometimes called quartz, occurs in crystalline and amorphous forms; it is colorless, infusible at ordinary temperatures, insoluble in water and in all the acids except hydrofluoric. The amorphous and gelatinous varieties are partially soluble in alkaline carbonates, but quite soluble in caustic alkalies. Silica combines with the bases to form silicates.

A variety of quartz well suited for use in the manufacture of porcelain teeth is found in great abundance in Pennsylvania and other parts of the United States. It occurs in large irregular masses, white in color, and very difficult to powder. It is used for the purpose of giving stability and firmness to porcelains, and its infusibility stiffens and keeps the other materials in shape, so that an object made of porcelain may preserve its molded form while exposed to the high temperature during the fusing process. For these reasons it is incorporated with feldspar and clay, and is looked upon as the "main prop in tooth body," in which it is just as essential for the purpose of lessening fusibility as flux is essential in enamels, which are required to fuse more readily.

Quartz must be ground under water to an impalpable powder. The proper degree of fineness may be ascertained by placing a small portion of the powdered quartz on the end of the tongue: if it is found to be without grittiness when rubbed against the teeth, it may be dried for use.

The preliminary steps in the reduction of this hard mineral to a fine state of division consist in heating to a bright redness as large pieces as the muffle of a furnace will admit, and dropping them into cold water; this causes the quartz to crumble into pieces the size of a pea, which are further reduced in a Wedgwood mortar by the succesive blows of a heavy pestle until fine enough to pass through a No. 10 bolting-cloth sieve, after which it may be brought to the state of an impalpable powder by grinding with water either in an ordinary hard porcelain mortar, or, when it is prepared in very large quantities, by one of the powerful grinding mills, turned by steam, in use at the large manufactories.

Clay.—This is a hydrated silicate of aluminum, and when pure may be represented by the formula $(2Al_2O_3,3SiO_2) + 3H_2O$. It is formed by the long-continued action of air and water upon granite rock, the disintegration of which is probably due to both mechanical and chemical causes. Mechanically, the rock is continually broken down by variations of temperature and by the congelation of water within its minute pores. Chemically, the action of water containing carbonic acid tends to remove the potash from the feldspar and mica in the form of carbonate of potash, whilst the silicate of aluminum and the quartz are separated by the action of the water: the former, being the higher, is separated from the heavy quartz, and, when again deposited, constitutes clay.

Kaolin is a pure quality of clay from which such impurities as sand and mica have been carefully excluded by washing, which is accomplished by mixing the clay with a large amount of water in a basin-shaped vessel. It is at first thoroughly stirred, and then, after sufficient time has been allowed for the sand to settle, the upper or lighter layer is poured or run off into another vessel. It is then permitted to stand until the kaolin subsides to the bottom of the vessel: the water is siphoned off;

the kaolin is then dried, when the mass may be turned out and the bottom scraped free from any sand found adhering to it.

Clay is infusible in an ordinary furnace when heated alone, but readily unites with feldspar, at high temperature, when incorporated with it, and is an element of strength in porcelain compounds.

Kaolin should be thoroughly mixed with the other ingredients of the body while in the dry state, and complete admixtures may be attained by passing the dry body through a No. 9 bolting-cloth sieve.

German clay is imported from Europe, and is used to manufacture various articles which require an infusible silicate of aluminum.

Formulas for Body.

The formulas for bodies and enamels used by manufacturers to-day are, of course, trade secrets. The following, taken from the *American System of Dentistry*, Vol. II, p. 962, are the well-tested standard bodies of Dr. W. R. Hall, and give an idea of the proportion of the ingredients:

Bodies for Molded Block Teeth.

I.		II.	
Kaolin	1 oz.	German clay	½ oz.
Silica	3 "	Silica	3 "
Feldspar	18 "	Feldspar	18 "
Titanium oxide	65 gr.	Titanium oxide	65 gr.
Starch, 10 gr. to each oz.		Starch, 10 gr. to each oz.	

It was formerly the custom of makers of molded teeth to at first partially burn or biscuit-bake the teeth or blocks. The addition of starch or gum tragacanth to the body does away with the necessity of the "first burning," as it gives the teeth sufficient firmness to allow of their being safely handled during the process of trimming, which must be done before the final burning. The titanium oxide and the starch are placed in a mortar and ground, at first without water; kaolin and silica are then added, ground together, and sifted through a No. 9 bolting-cloth sieve: the feldspar is then added, and after sieving a second time the mixture is ready for use, and should be kept in a covered glass jar. As it is often desirable to have in stock a small variety of bodies of different shades, it will be found of great convenience to have attached to each jar a test sample of the body which has been burned in the furnace, so that the color and texture may be ascertained without loss of time.

In preparing bodies and enamels for use in molds they are mixed with water, and then dried to the consistence of dough, when they are placed in the molds with small spatulas. The enamels being laid in the face side and the body in the pin side of the molds, these two halves of the mold are then adjusted to each other, placed in a strong press until in complete contact, secured by a strong clamp, and exposed to a heat sufficient to bake the starch or gum, which so hardens the teeth or blocks that they will withstand a very considerable amount of force without danger of breaking. During the burning of the teeth the starch or gum burns out without injury to either the body or enamels.

At the present time in most manufactories, no difference is made in the composition of the enamels and bodies save in the matter of their coloring constituents. The body is generally somewhat yellower, due to the titanium oxide. The body and enamel are so placed and proportioned on the face side of the mold as to give the same gradations of color to the artificial tooth which are observed in the natural teeth. We have thus "point" and "base" enamels to give the correct colors to these portions of the porcelain tooth.

In bodies used for carved blocks no starch need be used. The work being done entirely by hand with small knives, it is essential that the material should be plastic enough to cut with facility, while it possesses sufficient toughness to permit of careful handling. These conditions are obtained by simply mixing the body with water, the kaolin present furnishing the desired plasticity.

COLORS USED IN THE MANUFACTURE OF PORCELAIN TEETH.

The colors used in imitating the tints of the natural enamel, dentin, and gums are produced by thoroughly incorporating titanium oxide and preparations of gold, tin, platinum, iron, and cobalt with the mineral substances of which porcelain bodies and enamels are composed.

Color frits are made by grinding the metal or its oxide with feldspar and a fine quality of glass, which serves as a flux to lower the fusibility of the enamel. The levigation is continued until a very fine state of division is reached, after which they are biscuit-baked in the muffle of a furnace. When cool the frit is removed and pulverized in a Wedgwood mortar, which has first been thoroughly scoured out by grinding with coarse silica to effectually remove traces of any coloring pigment previously prepared in the same mortar.

In grinding prepared platinum or gold-foil the feldspar and flux are added by small portions at a time until the greatest degree of fineness is attained. The shade of the enamel will depend largely upon the state of minute division of the metal or oxide. As an example it may be stated that distinctly different shades may be made from portions of the same mixture by reducing one lot to extreme fineness and leaving the other comparatively coarse.

FRITS.

William R. Hall's formulas :

Platinum Frit, Blue.

Platinum (dissolved in aqua regia)	1 dwt.
Feldspar	1 oz.
Plate glass	20 gr.

Platinum Frit, Gray.

Platinum frit	30 gr.
Titanium oxide	10 "
Gold frit	100 "

Cobalt Frit, Azure Blue.

Smalt (cobalt)	60 gr.
Titanium oxide	6 "
Gold frit	60 "
Feldspar	1 oz.

Iron Frit, Gray.

Iron scale	4 gr
Titanium oxide	1 "
Gold frit	60 "
Feldspar	1 oz.

Gold Frit, Reddish-brown.

Pure gold-foil	12 gr.
Plate glass	20 "
Feldspar	1 oz

Dr. William R. Hall's directions for preparing the platinum and gold frits are as follows: "The metal for the *platinum frit* is dissolved in boiling nitro-muriatic acid, care being taken not to use more acid than is just sufficient to make a saturated solution. When cold the spar and glass are added and mixed with a glass rod, and placed in a clay crucible previously washed inside with powdered quartz mixed with water. A cover must be closely fitted to the inner edges of the crucible, the joint being carefully closed or luted with clay and quartz, and burned as has been described."

"The metal of the *gold frit* is dissolved in cold nitro-hydrochloric acid; with this exception it is treated in the same way as in the directions for the platinum frit."

Prof. Wildman, who called the gold frit "*silicate of gold*," directed that "coarse feldspar 120 gr., gold-foil 10 gr., flux 8 gr. be placed in a mortar and ground until the gold is entirely cut up; it is then made into a ball, placed on a slide, and fused in the muffle; then made fine, ready for use." His gold "mixture" was made by dissolving 8 grains of gold-foil in aqua regia, to which were added and well stirred 300 grains of very finely pulverized feldspar. When nearly dry the mixture was formed into a ball and fused on a slide in the muffle of the furnace, after which it was pulverized and kept dry for use.

Sponge platinum is a gray, loosely coherent form of finely divided platinum that readily absorbs certain gases, as oxygen, and is used as an oxidizing agent.

Sponge platinum is made by dissolving pure platinum filings or scraps in six times their weight of nitro-hydrochloric acid composed of 1 part of nitric to 3 parts of hydrochloric. The platinum and mixed acid should be placed in a clean Florence flask and heat gently applied by means of a sand bath, for the purpose of facilitating the action of the acid on the metal. The heat should not be too great, otherwise the effervescence will be so violent that a portion of the mixture may be ejected from the flask. Should effervescence cease entirely before all the metal is dissolved, the fluid must be decanted and more acid added until the last particle of the platinum disappears. The solution is then poured into an evaporating dish and evaporated on the sand bath until the mass is nearly dry and the resulting salt assumes the crystalline form. At this part of the operation care must be taken that the temperature of the sand bath is kept below 450° F.; above that point decomposition of the platinic chloride takes place, when a portion of the chlorine is driven off, causing a precipitate of platinous chloride, which is of a greenish-gray color and insoluble in water. If, however, no such accident occurs, the platinic chloride will be of a reddish-brown color, very deliquescent and freely soluble in water. The crystallized salt is dissolved in pure distilled water, and allowed to stand until it becomes perfectly clear, when it is to be filtered, after which a cold saturated solution of ammonium chloride (sal ammoniac) is gradually added to the platinic chloride until all precipitation ceases. When the precipitate has entirely settled it is collected by pouring off the liquid, thoroughly washing the spongy metal, drying, and placing away for future use in small glass jars.

Iron scale is a loose coating of oxid which forms on heated iron during

the process of forging; when combined with spar it makes an exceedingly natural blue-gray color, suitable, when toned by combination with other frits, as designated in the formula of Dr. Hall, for the cutting edges of the teeth of young persons.

Cobalt, which has been mentioned as one of the occasional coloring ingredients in enamels, is what is known in commerce as "smalt." It is sometimes used in producing the brighter shades of blue. It is not, however, a permanent color, and it requires to be associated with some other color, such as platinum, to prevent it from being lost during the burning of the teeth.

In preparing coloring frits it should be borne in mind that a too high or long-continued heat may reduce the oxides to a metallic state, and thus ruin them for use as coloring pigments. The burning should either be done in the muffle of the furnace or in a white-clay crucible provided with a top securely luted in and made perfectly tight with a mixture of silica and kaolin, for the purpose of protecting the frit from the action of the fuel gases. The burning should be done at a temperature sufficiently high to glaze the frit, and the crucible need not be placed in the furnace until that point has been nearly attained, otherwise the first might deteriorate in its color-giving qualities by too long exposure to heat.

ENAMELS FOR PORCELAIN TEETH.

The enamels of Professor Wildman were more fusible than those of William R. Hall, and were probably not as well adapted for molding and general manufacturing purposes as were those of the latter, though in translucency, texture, and color they were unsurpassed.

The making of bodies and enamels and their application require both skill and experience. There should also be a correct relation of fusing points between bodies and enamels. As the fusibility of the bodies of Hall and Wildman probably differ, it would not do to use the enamels of one with the bodies of the other.

Professor Wildman's Formulas for Point and Base Enamels.

No. 1, for Points (Gray).		*No. 2, Neck or Base (Yellow).*	
Feldspar	1 oz.	Feldspar	1 oz.
Silicate of gold	6 gr.	Titanium oxide	8 gr
Prep. sponge platinum	4 "	Prep. sponge platinum	4 "
Flux	20 "	Flux	24 "

No. 3, Yellow.		*No. 4, Gray.*	
Feldspar	1 oz.	Feldspar	1 oz
Titanium oxide	8 gr.	Titanium oxide	$1\frac{1}{2}$ gr
Prep. sponge platinum	4 "	Prep. sponge platinum	4 "
Gold mixture	25 "	Light cobalt ashes	4 "
Flux	24 "	Flux	24 "

No. 5, Blue

Feldspar	1 oz.
Sponge platinum	3 gr.
Light cobalt ashes	2–3 "
Flux	24 "

Dr. William R. Hall's Formulas for Enamels.

It will be observed that the enamels of Dr. Hall have no flux as an ingredient other than that which is contained in the different frits. In this respect they differ materially from the formulas of Prof. Wildman. On the ground that fluxes give a glassy surface to the finished teeth and decrease the beauty of good spar, Dr. Hall asserts that none should be used in enamels.

Platinum-gray, No. 1.		*Platinum-blue, No. 1.*		*Iron-gray, No. 4.*	
Plat.-gray frit	1 gr	Plat.-blue frit	1 gr.	Iron-gray frit	4 gr.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.	Starch	15 gr.
No 2.		*No. 3.*		*No. 6.*	
Plat -gray frit	2 gr.	Plat.-blue frit	3 gr.	Iron-gray frit	6 gr
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz
Starch	15 gr.	Starch	15 gr.	Starch	15 gr
Platinum-gray, No. 4.		*Platinum-blue, No. 5.*		*Iron-gray, No. 8.*	
Plat.-gray frit	4 gr.	Plat.-blue frit	5 gr.	Iron-gray frit	8 gr.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.	Starch	15 gr.

Gold-yellow, No. 1.		*Gold-yellow, No. 2.*		*Gold-yellow, No. 3.*	
Titanium, pure	1 gr.	Titanium, pure	2 gr.	Titanium, pure	3 gr.
Gold frit	2 "	Gold frit	4 "	Gold frit	6 "
Starch	15 "	Starch	15 "	Starch	15 "
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.

Brown-yellow, No. 1.		*Brown-yellow, No. 2.*	
Titanium, pure	1 gr.	Titanium, pure	2 gr.
Platinum frit	1 "	Platinum frit	2 "
Gum frit	4 "	Gum frit	8 "
Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.

GUM FRIT (PURPLE OF CASSIUS).

Gum frit, as its name implies, is for the purpose of imparting the pink color to the gum portion of a gum section. It derived its name of "Purple of Cassius" from the German chemist, Andreas Cassius.

The dry method, originated by the late Prof. Wildman, is the one now employed by manufacturers of porcelain teeth in the preparation of this frit. Pure silver 240 gr., pure gold 24 gr., and pure tin $17\frac{1}{2}$ gr. are placed in a crucible, with sufficient borax to cover the mass, and melted. In order to ensure a thorough mixture of the different metals the melted mass should be poured from a height into a vessel of cold water, and this process of granulation should be repeated at least three times; but at every melting the alloy should be well covered with borax

to prevent loss of tin by oxidation. The vessel into which the molten mass is poured should be a wooden one.

The component parts of the alloy have now been thoroughly incorporated, the next step is to collect the granulated mass and separate from it any adherent particles of glass or borax. The metal is then put into a glass or porcelain evaporating dish (the Berlin porcelain is the best), and sufficient chemically pure nitric acid is added to cover the metal. The dish is now placed over a sand bath, and gentle heat applied and continued until chemical action ceases. If at this point it is found that all the metallic particles are dissolved, the dish may be removed from the bath. Should any solid particles be found in the solution, a little more nitric acid must be added and the operation continued until all are dissolved. The silver having been entirely dissolved by the nitric acid, the solution should be poured off and the remaining oxide carefully washed until the last trace of silver is removed. After several washings with a large quantity of pure warm water the latter should finally be tested with a clear solution of common salt, and if it remains clear, without show of milkiness, the silver is all removed. When the oxide is sufficiently washed the purple of Cassius should be dried by gently heating, after which it is ready to be incorporated with the silicious materials.

The process of making gum enamel is divided into three stages: first, the preparation of the oxide; second, fritting, or by the aid of heat uniting the metallic oxide with the silicious base; third, diluting the frit so as to form the desired shade. The frit is formed by mixing 8 grains of the metallic oxide (purple of Cassius) with 700 grains of feldspar and 175 grains of a flux. The oxide is placed in a smooth Wedgwood mortar and ground as fine as it is possible to get it. The flux is then added in small quantities and the levigation continued, after which the feldspar may be added and treated similarly. It is of the highest importance that the mass be reduced to the utmost degree of fineness, and an expert workman will spend six or eight hours at least in levigating the quantity given in the formula. While the mass is being ground in the mortar foreign substances, such as small particles of wood, etc., must be carefully excluded; otherwise during the vitrefying process these will be converted into carbon, which will be sure to reduce a portion of the gold in fine metallic globules distributed throughout the mass.

The vitrefying or fritting process consists in packing the mass, after the most thorough levigation, in the whitest sand crucible that can be obtained. (Dark-colored crucibles are liable to injure the frit by contamination with iron.) This must be provided with an accurately fitting cover made of the same material, or a suitable top may be formed of a piece of slide such as is used in burning continuous-gum work. Before placing the frit in the crucible the interior surface of the latter should receive a thin coating of very fine quartz, made into a paste with water, to prevent the frit from adhering to it during fusion. The frit in the dry state is then packed in, and the cover tightly luted to its place with

kaolin. The crucible is then buried in a strong anthracite coal fire, remaining there until the contents are fused. The time required to do this will depend upon the size of the crucible and the intensity of the heat. Any ordinary coal stove provided with a good draught will answer, but the fuel must be packed around and over the crucible, and the heat carried to the highest attainable point. Usually about two hours will be required to thoroughly fuse the mass, after which it is removed from the fire and permitted to cool.

The vitrefied mass is removed from the crucible by breaking the latter. Every particle of adhering quartz or portions of the crucible should be cleared from the surface. It is then pulverized to a fineness which will allow it to pass through a No. 10 bolting-cloth sieve, and is ready for the third stage in the preparation of gum enamel, which consists of diluting the frit with the proper amount of feldspar. As the strength of the coloring pigment varies according to the degree of fineness attained during the levigation, it is usually necessary to make several tests in order to arrive at the desired shade. This is accomplished by mixing separately several different lots in the following proportions:

Gum frit . .	1 part;	Gum frit . .	1 part;	Gum frit . .	1 part;
Feldspar . .	2 parts.	Feldspar . .	3 parts.	Feldspar . .	4 parts.

These are applied to marked pieces of porcelain body and fused in the usual way, the result determining the proportions necessary to produce the desired shade.

Formula for Flux (Glass) for Reducing the Fusing Point of Enamels.

White bottle-glass, which does not contain lead or iron, may be used as "flux" to reduce the fusing point of enamels, but owing to the uncertainty of the composition of glass, most of the manufacturers of porcelain teeth make a fine glass for this purpose after the following formula, the ingredients of which are first ground separately, then thoroughly mixed, and placed in a white crucible provided with a cover (which must be tightly luted) and thoroughly fused. If perfectly pure materials are used, the result will be an exceedingly brilliant, colorless, and transparent glass:

Finely powdered silica	12 oz.
" " glass of borax	3 "
Potassium carbonate	3 "

Formulas for Continuous-gum Work.

Bodies and enamels intended for use in the "continuous-gum" process must necessarily be more fusible than the materials of which teeth are composed, in order that the latter may not be affected by the three heatings the denture must be exposed to before it is completed. It will therefore be noticed that an unusual amount of flux enters into their composition. The formulas herein given are those of well-known experts in continuous-gum work.

Continuous-Gum Formulas of Dr Hunter.

Flux:	Quartz	8 oz.	Fuse in crucible to form glass; when cold reduce to powder.
	Calcined borax	4 "	
	Caustic potash	1 "	
Granulated Body:	Spar	2 oz.	Fuse in crucible, and powder to pass through No. 50 wire sieve.
	Quartz	1½ "	
	Kaolin	½ "	
Body:	Flux, as above	1 oz.	Grind the first two articles very fine, then add granulated body, which is mixed with the fine without grinding.
	Asbestos	2 "	
	Granulated body	1½ "	
Gum Enamel:	Flux, as above	1 oz.	Grind very fine and semi-fuse in crucible; powder coarsely for use.
	Fused spar	1 "	
	English rose-red	40 gr.	

Formulas of Dr. D. D. Smith.

Granulated Body:	Quartz	20 gr	Grind fine and fuse on slide in furnace; powder coarsely for use.
	Spar	24 "	
	Caustic potash	1 "	
	Titanium	2 gr.–1 oz.	
Flux:	Quartz, very fine	18 dwt.	Fuse same as above, and grind very fine.
	Spar	10 "	
	Glass of borax	2 "	
	Cryolite	1 "	
	Caustic potash	10 gr.	
	Titanium	1½ gr.–1 oz.	
Gum Enamel:	Gum frit of (S. S. White)	4½ dwt.	Fuse and grind for use.
	Flux without titanium	16 "	
	Granulated body	11 "	
	Cryolite	7 "	

Dr. Moffit's Formula for Continuous-Gum Body.

Body:	Spar	12 oz.	Grind coarsely.
	Quartz	4½ "	
	Bohemian glass	60 gr.	
	French china	35 "	
	German clay	2 dwt	

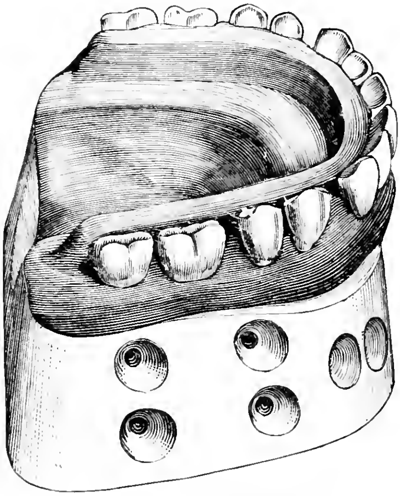
No gum-enamel formula came with this. Dr. Smith's formula for gum enamel will do for the above, minus the cryolite.

THE PROCESS OF MANUFACTURE OF PORCELAIN TEETH.

Brass Molds for Porcelain Teeth.—The manufacture of molded teeth as carried out upon the extended scale of the present day, to meet the demands of the trade, requires the use of a large number of brass molds of various sizes and forms. In the best factories a "pattern" mold of each of these is kept as a standard to preserve the uniformity of the product. It is not used in molding teeth, but serves as a pattern, from which are secured the "duplicate" molds actually employed in manufacture.

Mold-making includes the carving of the plaster blocks, making the plaster pattern of the mold, casting it in hard brass or bronze, and the "cutting" or finishing of the mold.

Fig. 115.



Tooth blanks arranged on cast.

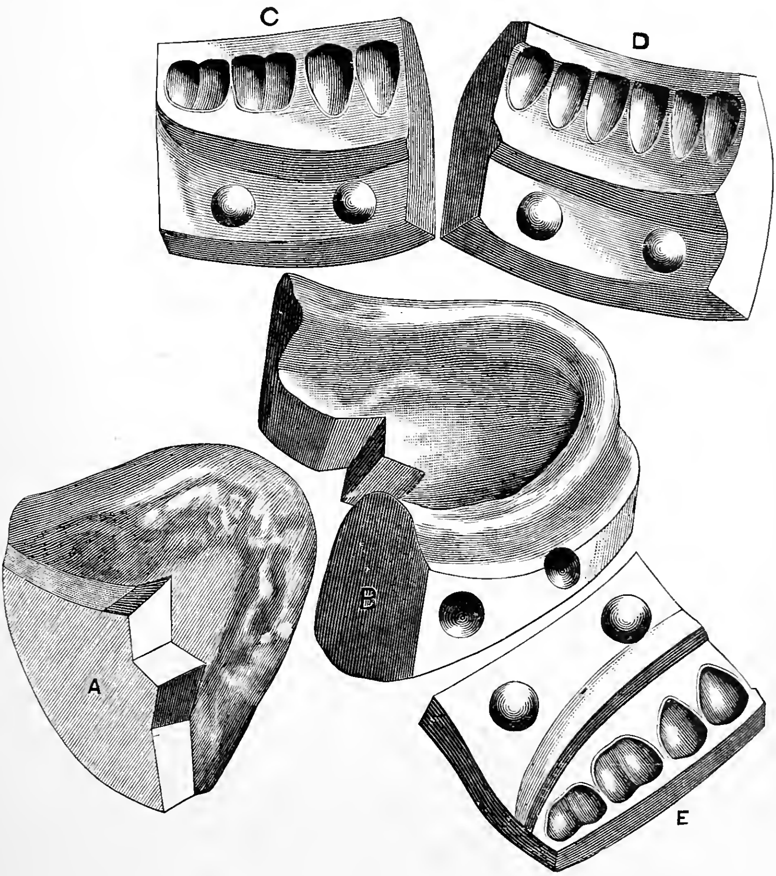
The plaster blocks constitute the design, and are a complete set of block teeth carved in plaster with allowance made for shrinkage and other changes which take place in the vitrefying process. This part of the work must be done by an artist, and one who has knowledge of the several classes of human teeth. These designs should always be made from natural teeth.

Dr. J. Leon Williams, of London, is at the present time preparing a set of molds, 36 in number, providing 12 types, with 3 sizes in each type. These molds, it is hoped, will provide a range of selection for any but the most extraordinary cases. The original models are being carved with the greatest attention to anatomical form and are, in the sets for edentulous cases, to be articulated in the original to provide for a minimum amount of grinding in articulation of the porcelain reproductions. The plaster blanks are arranged on a rim of wax similar to articulating wax; the gums are formed of paraffin or the pink combination of paraffin and wax; broad spaces are left between the centrals; the cuspid and first bicuspids and the second bicuspids and first molars, as sectional blocks for an entire upper denture, are divided into six pieces. Each block must be provided with a slight excess of material at the joint, to afford sufficient latitude in fitting them together. A wall of plaster about one-fourth of an inch in thickness is run on the outside of the model, so as to include the entire set of blanks; when hard enough it is trimmed so as not to exceed in height the cutting edges of the tooth blanks, varnished, and oiled; an inside wall is then made of plaster of the same height as the outside one. The inside wall is removed when hard in one piece; the outside one is cut into six pieces with a thin saw

blade, the cut being made between the centrals, the canines and bicuspids, and the bicuspids and molars at the spaces shown in Fig. 115. The sections thus made are then separated from the model.

Both the outside and inside walls are trimmed, varnished, and laid aside to dry. The removal of the blanks from the model is next in order, and both walls are given a coating of shellac varnish. Fig. 116 shows the walls made for a lower set of plaster blocks. The walls are now to be placed on the model and secured in position with twine or wire; they are then oiled, and plaster mixed to the consistence of cream is first painted over the surface, as representing the teeth, with a camel's-hair brush, when the residue is run in between the inside and outside

Fig. 116



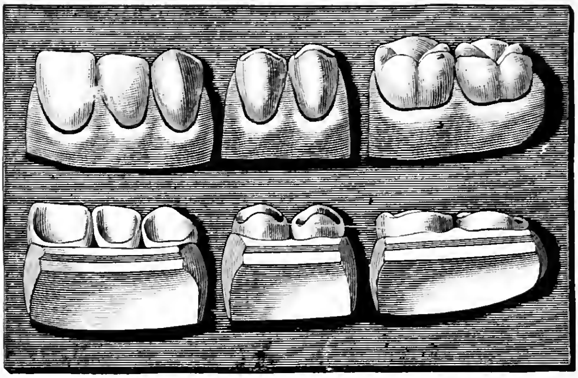
View of the walls and cast, separated.

walls and allowed to set thoroughly before removal. If the plaster has been carried into all depressions and interstices between the walls, a continuous set of plaster blocks will be the result. These are separated into six sections by means of a thin saw blade, as shown in Fig. 117, the six front teeth in two sections of three each, the first and second bicus-

pids of each side in two other sections; the molars are divided in the same may. These plaster blocks now require trimming on the inside, the carving of the masticating surfaces of the bicuspids and molars in imitation of the natural organs, and the cutting of a recess for the pins, as seen in Fig. 117.

The ends of the blocks, or those parts technically called the joints, must be trimmed so that they will taper sufficiently to ensure their safe

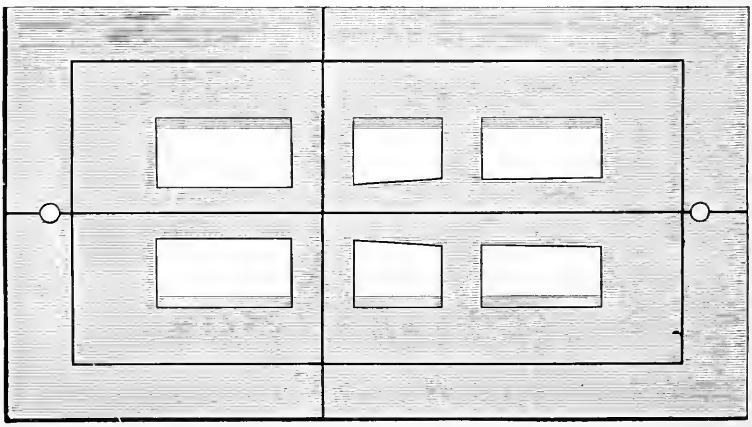
FIG. 117



Plaster blocks, finished

delivery from the plaster mold, as shown by the pin sides of the plaster blocks in Fig. 117. If not properly bevelled at all points, so that no undue retention will occur, it may be necessary to remove the pattern blocks piecemeal. The plan of such a mold would then be found to be defective and, as may readily be surmised, it would not be possible to

FIG. 118



Foundation plate.

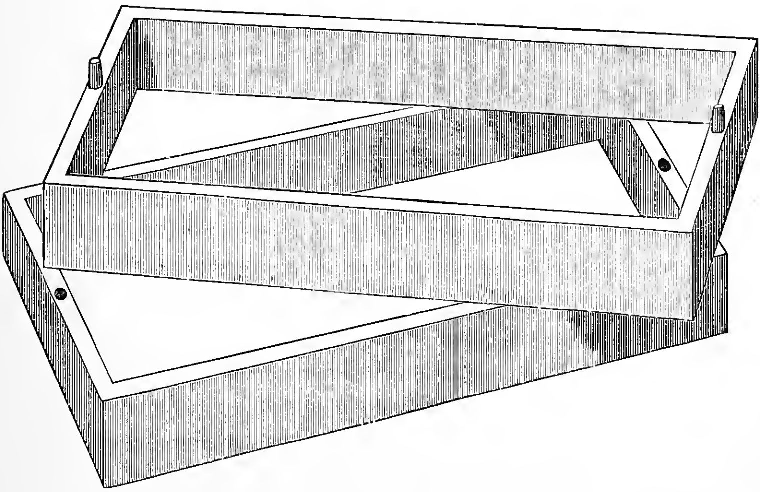
obtain a brass mold from a pattern in which so serious a fault existed. After these details have received careful attention and the blocks have

been trimmed and carved to the satisfaction of the workman, they should receive at least two coats of shellac or sandarac varnish.

The Plaster Mold.—The preparation of the plaster mold is the second part of the process of mold-making, the first part being the modelling of the designs in the form of plaster blocks. These designs are really the foundation of the whole system, and require in their production artistic talent and knowledge of the forms of the different types of human teeth. With the exception of the cutting or finishing of the brass mold, the rest of the process is purely mechanical.

By referring to Figs. 122 and 123 it will be seen that the finished mold consists of five pieces—the face side, the pin side, two end or crown pieces, and a key piece. These pieces have all to be made in plaster to serve as patterns from which to cast fac-similes in brass. The plaster blocks are arranged on a foundation plate. This plate can be

Fig. 119



Brass frame.

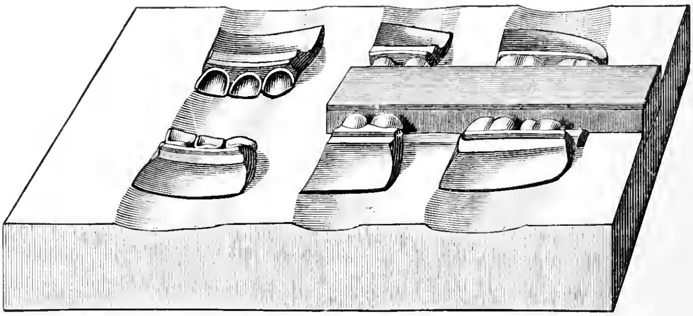
made of brass or zinc, as shown in Fig. 118, $5\frac{1}{2}$ inches long, 3 inches wide, and $\frac{1}{4}$ of an inch thick, with oblong recesses to receive the blocks—those for the front blocks 1 inch long and $\frac{1}{2}$ an inch wide; those for the bicuspids, $\frac{3}{4}$ of an inch long and $\frac{1}{2}$ an inch wide; and those for the molars $\frac{7}{8}$ of an inch long and $\frac{1}{2}$ an inch wide. The black lines on the plate are used as guides to measure from in placing the blocks; the round holes at the ends are to receive the pins seen on the frames in Fig. 119.

The plaster blocks are placed on the foundation plate faces upward, with the cutting edges opposite to each other, as seen in Fig. 120, and are then secured in position with beeswax, clay, or putty, which also marks the correct line of division between the two halves of the mold. This is a very important detail of mold-making; upon its correct management depend the successful application of the enamels and the safe delivery of the molded porcelain blocks. This line of division should extend along the middle of the cutting edges of the incisors and canines

and the gum edge, but should include but little of that portion of the block called the joint. By referring to Fig. 121 the reader will see that the face side of the mold gives merely the distinct outline of the entire face of the block, and that the bulk of the block is represented in the pin side; yet the edges of the face side of the blocks should be sufficiently well defined to assist in holding the enamels in position when the mold is pressed together. The front blocks are secured to the plate $\frac{2}{16}$ of an inch from its centre line; the bicuspid blocks, $\frac{3}{16}$ of an inch from the line; the molar blocks, $\frac{4}{16}$ from the line. The side blocks are arranged farther apart at the end near the molars than at the other, to allow for a tapering key, as shown by *C* in Fig. 123. If all spaces between the block and the foundation plate have been stopped with clay or putty, the plate with arranged blocks is ready for the frame.

The frame is in two sections made of polished brass, one section made to articulate with the other by means of pins and corresponding holes, as seen in Fig. 119. The inside tapers so that the plaster mold when hard may deliver without difficulty. These frames measure $4\frac{3}{4}$ inches in length

Fig. 120



Pin side of plaster mold, with plaster blocks and wax in position.

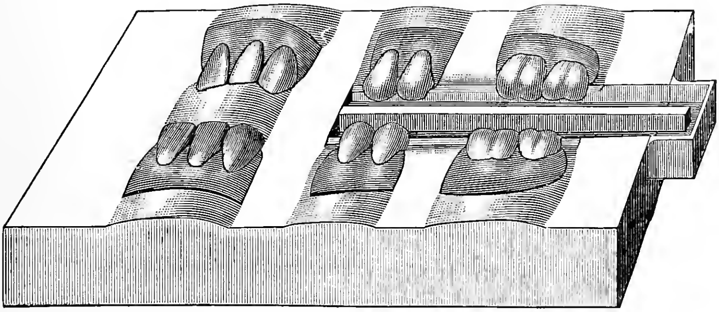
and $2\frac{3}{8}$ inches in width, each section being $\frac{3}{4}$ of an inch high with a thickness of $\frac{1}{4}$ of an inch. The part with pins is well oiled on its inside and placed on the plate. The plaster blocks having been oiled, the plaster is mixed by dropping it into water and allowing it to settle without stirring, so as to exclude air; the excess of water is then poured off; the blocks carefully coated with thin plaster by means of a small camel's-hair pencil; the rest of the plaster is then poured in and levelled off even with the top of the frame with a spatula. When the plaster becomes hard the plate is removed and the face side of the pattern is secured.

The blocks are then carefully taken from the face side of the plaster mold, and, if any of the edges are broken, they must be repaired with wax or plaster and made smooth. After the removal of the blocks the mold must be varnished with shellac or sandarac and allowed to dry thoroughly, when the blocks are replaced. The space between the bicuspid and molar blocks is filled by a piece of wax, as seen in Fig. 120, to form the depression intended for the end pieces and key in the pin side of the mold. The whole fixture is then thoroughly saturated in clean water, the surfaces coated lightly with oil, and the other section

of the brass frame placed in position and filled with plaster mixed and applied in the manner previously described; this forms the pin side of the mold. The two sections are easily separated when the plaster has hardened sufficiently by introducing a knife blade between them and carefully prying apart. The plaster blocks will usually be found in the pin side of the mold, because the greater portion of the block is embraced in that part of it, and consequently offers more surface for retention than does the face side. The brass frames are next to be removed from each part of the plaster mold by tapping the former gently with a small wooden mallet. The blocks are then to be removed from the pin side of the mold; this must be done with the greatest care by inserting a sharp excavator or knife point under the block and gently prying it out. If any part of the mold is broken and carried away with either of the blocks, the piece may be fastened back to its proper place with thick shellac varnish, or, if lost, the defect may be repaired with beeswax.

The crowns or masticating surfaces of the bicuspids and molars are formed by end pieces held in place by a wedge-shaped piece of brass,

Fig. 121

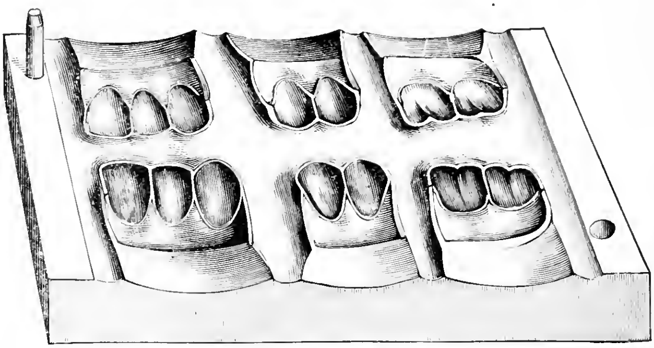


Face side of plaster mold, with temporary key.

as shown by *A*, *B*, and *C*, Fig, 123. The wax seen in Fig. 120 must be taken away from between the side blocks, and the blocks removed and carefully cleaned; the space formed by this piece of wax must be trimmed so as to increase its width about $\frac{3}{16}$ of an inch, its floor made perfectly flat and its sides perpendicular, and arranged to taper toward the end nearest the front blocks, where it should be slightly narrower than at the molar end of the space. This space at its floor and sides must be level and true, or the crown pieces and key *A*, *B*, *C*, (Fig. 124) will not fit well in the finished mold; the surface of the recess is then varnished. A temporary key of brass is placed midway in this space and secured with wax, as shown in Fig. 121, and allowed to extend a quarter of an inch beyond the end of the mold. The plaster mold is then oiled and put in water to drive out the air; the side blocks are oiled and put in place; the face side of the mold is oiled and put in position, and the two sides tied together. Plaster, mixed thin, is then run into the spaces on each side of the temporary key, extending beyond the mold to the end of the key. After the plaster is hard the temporary key is carefully drawn out by means of pliers, when the crown pieces

may be easily removed. All the parts of the plaster mold are now to be thoroughly dried by gentle heat; grooves are then cut around each block in both sides of the mold to allow for the escape of the excess of body and enamel usual in molding teeth. All parts of the plaster mold must be made as smooth and perfect as possible, as its condition, whether good or bad, is duplicated in the brass castings, where it is much more

Fig. 122

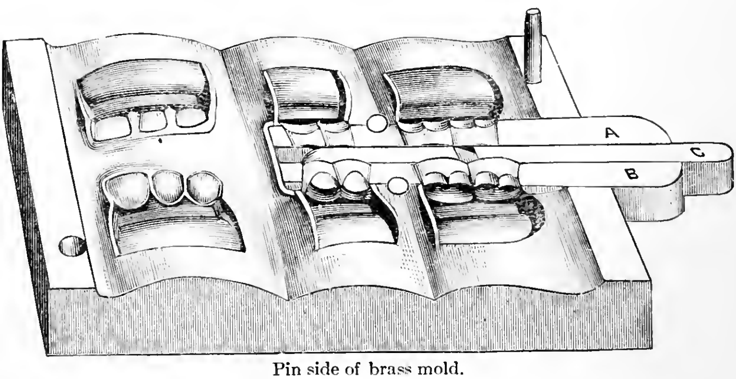


Face side of brass mold.

difficult to correct imperfections or faults than in the plaster. When entirely finished and thoroughly dried all the parts of the plaster mold are to be varnished with shellac and allowed to dry thoroughly, when they are ready to be sent to the foundry to be cast in hard brass.

Fig. 122 shows the face side of the finished brass mold. Fig. 123 shows the pin side: *A* and *B*, the crown pieces; *C*, the key. Retaining

Fig. 123



Pin side of brass mold.

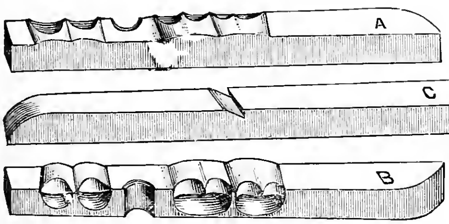
pins of brass are put in to prevent movement of the crown piece during molding; the heads of these are seen in Fig. 123 between the molar and bicuspid blocks.

Cutting and Finishing Brass Molds.—Brass or bronze, like other hard metals, when cast will shrink somewhat, and thus the brass casting becomes smaller than the plaster model of which it is a fac-simile: in finish-

ing the surface of the depressed teeth and gums in the brass mold the workman will necessarily enlarge to some extent the reversed representation of the blocks to the original size of the plaster models, and the work should be done with such precision that the latter can be placed in the brass mold and fit as though they had been molded in it.

After fitting together the two sides of the mold, trial blocks of plaster should be made to ascertain if the outlines of the blocks meet properly. The trial blocks, made by pressing plaster between the two halves of the mold, will indicate any defect in adjustment. If, however, it is found that the outline edges are quite together, and that the relation of one half to the other is correct, the guide pins are to be put in, in order that the relation of the parts be permanently fixed. This is done by firmly holding the two parts of the mold in a steel clamp, and then drilling the holes for the pins entirely through each side with a $\frac{3}{16}$ of an inch drill. One of the guide pins is placed in the face side of the mold opposite the right central, the other in the pin side opposite the left molar. They must be permanently screwed, one on each side of the mold, as shown in Figs. 122 and 123. After the holes are drilled, the one in the face side opposite the central and the one in the pin side opposite the

Fig. 124



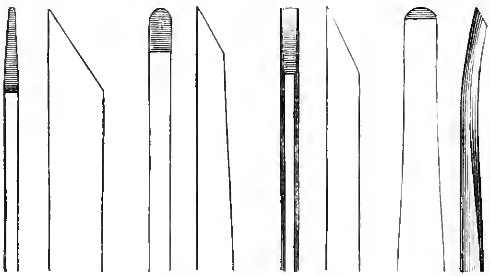
left molar must be screw-tapped to receive the screw end of the guide pins; the other end of the pins must taper slightly near its extremity so as to freely enter the hole opposite to it, but the pins must fit close enough to prevent lateral movement when the two parts of the mold are quite together. These pins should be made of steel wire not less than $\frac{3}{16}$ of an inch in thickness. The outside of the mold is then to be squared and finished; this may be done either in a lathe or by filing guided by the try-square and the callipers, for it is very important that the mold, when the two parts are together, should be uniform in thickness and perfectly level, as there is danger, if these conditions are not secured, of its being sprung out of shape by the press in molding teeth.

The next step toward the completion of the mold is the fitting of the end pieces in the space between the back blocks; the floor of the space must be filed perfectly flat and level, and the side made perpendicular; the crown pieces, where they are in contact with the key, are made smooth and true; the taper key, *C* (Fig. 124), is made to fit between them and holds the crown pieces securely against the perpendicular walls of the space alluded to above during the operation of molding teeth. This key is made longer than the crown pieces, so that it can be driven between them with a wooden mallet to facilitate its removal. To prevent

the crown pieces from sliding back while the mold is under pressure, two brass-headed pins are riveted in the pin side of the mold between the bicuspid and molar block, as shown in Fig. 123, the pin being partly in the mold and partly in the crown pieces.

The cutting and smoothing of the gums and faces of the teeth in the castings is not, as is generally believed, a very difficult mechanical operation; it does, however, require artistic skill and judgment. The fine lines of the plaster pattern are made less distinct by the casting of the metal. The gravers (Fig. 125) are to be employed to restore the definiteness of

Fig. 125



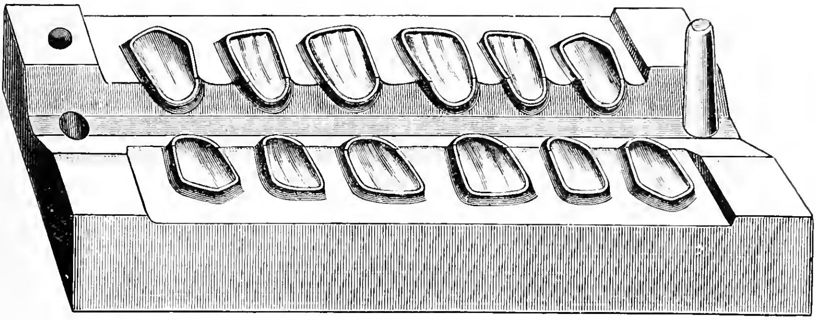
Gravers of Stub's steel.

outline and contour, and great care must be taken in doing this to avoid change or obliteration of the characteristic features of the original pattern. The gravers should be of the best quality of steel tempered to a straw color; they must be kept ground to a long bevel and a keen edge, the latter being made by means of an Arkansas stone; the gouge-shaped graver is used at first to cut a clean and smooth surface on the part of the mold representing the faces of the front teeth. A plaster set of teeth should then be made, which, on comparison with the original patterns, will indicate that further cutting is needed to bring the mold to correspond exactly with them. The pin side of the mold will require trimming with the flat or chisel-shaped graver to give it a smooth surface, and to bring the size to that of the original pattern, which should fit perfectly into the brass mold as though it had been molded there; and this is a good test for the accuracy of the brass casting.

During the cutting repeated trials should be made with plaster to see if the edges come properly together with no overlapping; and as the cutting proceeds it will be necessary for the workman to frequently see the reverse aspect of the teeth; this he does with black try-wax, which is made by mixing beeswax and lampblack with a few drops of turpentine. Small pieces of this wax are held in the hand while cutting, the warmth of the hand being sufficient to soften it; in this way the mold-maker is able to take impressions of the concavities of the teeth as the work proceeds. Care is required in carving the original patterns to form the margins around the necks of the teeth, so that they are sharp and sufficiently well defined to keep the gum enamel from mixing with the crown enamel when the mold is pressed. The mold-trimmer must be cautioned against obliterating this line of demarcation between crowns and gum.

When the mold is complete in respect to size and form of the teeth, another set of plaster blocks should be made in it, for the purpose of determining whether the blocks leave the mold readily when slightly tapped with a wooden mallet. If the blocks are difficult to remove, it will be evident that remaining points exist which retard their delivery; these are easily discovered by the abrasion they make upon the plaster,

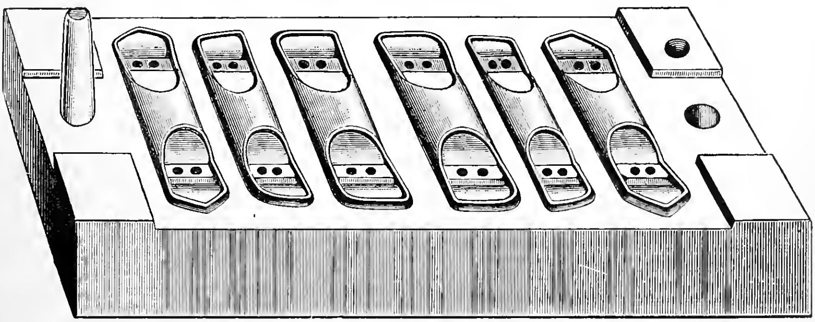
Fig. 126



Face side of mold for anterior plain rubber teeth.

and such points should be bevelled sufficiently to allow the blocks to drop from the mold without injury when gently tapped by the mallet on its sides or ends. Finally, small holes are to be drilled in the pin side of the mold for the platinum pins; these holes are drilled perpendicularly to the face of the mold and parallel with each other, five for each front block, four for the biscuspid blocks, and three for the molar blocks. The

Fig. 127



Pin side of mold for anterior plain rubber teeth.

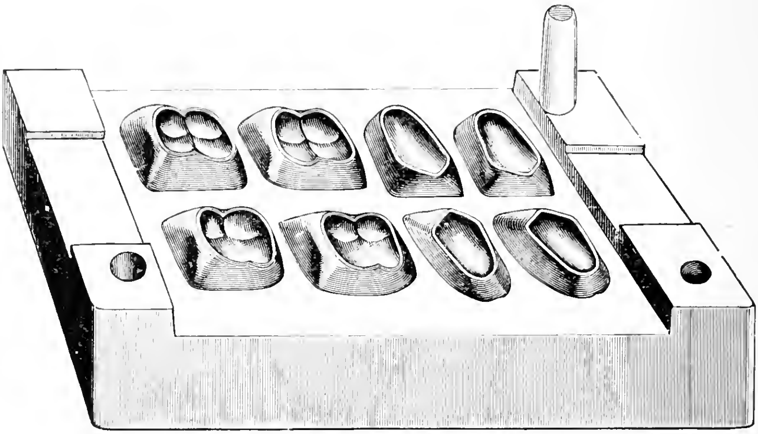
mold is now to be thoroughly cleansed of all particles of brass, and is ready for use.

Molds for plain teeth differ from those for gum-section teeth in that those for the anterior teeth and the molar and bicuspid teeth are made separate. The anterior mold, however, as will be seen in Figs. 126 and 127, is intended for two sets of teeth of the same pattern.

Molding and Burning Porcelain Teeth.—The first step in molding is to oil the brass mold and put the platinum pins in the small holes drilled

for their reception in the pin side of the molds. The point enamel is then put in the face side of the mold, and arranged with a small spatula to the full thickness at the point and tapered down sparingly toward the

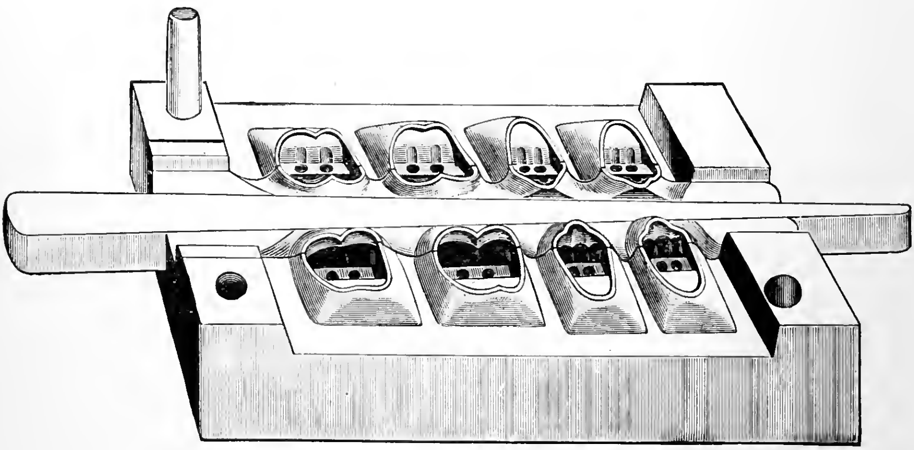
Fig. 128



Face side of bicuspid and molar mold.

neck. A thin coat of point enamel is placed on the lingual side of the front teeth and on the masticating surfaces of the bicuspids and molars. The mold is then laid aside to dry before placing the gum enamel in

Fig. 129



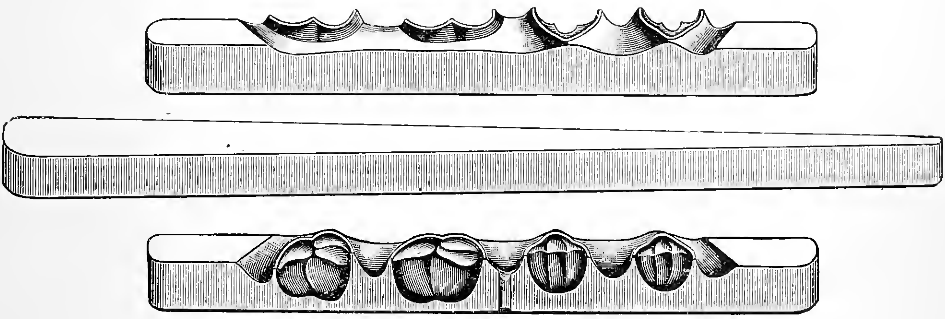
Mold for bicuspid and molar plain rubber teeth with crown pieces and key in position.

place. Some makers of teeth use but one enamel; instead of applying a yellow neck enamel, they allow the body to show at the neck of the tooth; this is probably done to save time and labor, but it does not afford the best results as to translucency and natural appearance.

The gum enamel is mixed with water and made just stiff enough to stay where it is placed by the enamel spatula, and is then spread evenly over the gum surface of the mold, the thickness being ascertained by touching the point of the spatula to the mold at every eighth of an inch. The placing of the enamel requires more experience than does any other part of the molding process. The gum enamel must be placed close to the necks of the teeth, but must not be allowed to impinge upon the crowns; when complete it is allowed to dry partially.

The body is applied in small pieces slightly in excess of the quantity needed for each block. These are taken up with a small spatula, formed into balls, and laid on the pins in the pin side of the mold. The two sides of the mold are then placed quickly together, put under the press, and the lever applied to force the two parts of the mold together. The mold is then taken from the press, put in an iron clamp, and screwed firmly together; it is then heated until the mold becomes hissing hot, when it is allowed to cool sufficiently to handle. The clamp is then removed, the mold opened, and the block made to drop out by striking the mold with a wooden mallet.

Fig. 130



Crown pieces and key.

If the heating has been carried to the proper point, the blocks will be found hard enough through the agency of the starch—which, it will be remembered, is an ingredient in the formulas for bodies for molded teeth—to admit of trimming; this is done with small files and separating saws. After trimming, the blocks are laid aside in complete sets for burning.

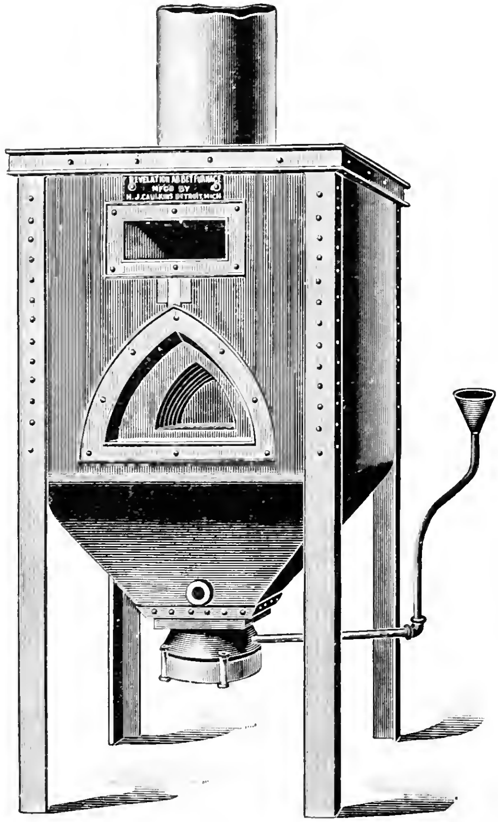
Burning.—In manufacturing on a large scale the blocks are arranged in complete sets on a fire-clay slide covered with coarse quartz. These slides are $6\frac{1}{2}$ inches in width by $9\frac{1}{2}$ inches in length; they have raised edges to retain the quartz which serves as a bed for the blocks; they hold from twelve to fifteen sets, according to the size of the blocks.

The furnaces used by the large manufacturers have a capacity of three or four hundred sets per day for one furnace (Fig. 131). These furnaces are square, with a heating oven directly over the fire, the muffle being placed lower down; the furnace is connected with the smokestack by flues at the top. The muffles are constructed of the best prepared fire-clay, 27 inches long, 8 inches wide, $5\frac{3}{4}$ inches high,

and 1¼ inches thick. The muffle must be thoroughly swabbed with clay mixed thin with water, to fill up all cracks or defects through which the gases from the fuel might enter the muffle. Such accidents are of frequent occurrence in burning, and are always ruinous to the teeth, the gas generally imparting to them a ghastly blue appearance.

As it is necessary to cool the blocks very gradually after burning to prevent cracking, they are placed in cooling muffles or ovens made of flat pieces of fire-brick about 12 inches square. These are built in tiers of ten in each row; each oven is provided with a loose fire-brick stopper

Fig. 131



Revelation oil furnace used for baking porcelain teeth.

The slide containing the teeth is placed in the heating muffle at the top of the furnace before burning; this preliminary heating prepares them for the higher temperature of the muffle, into which they are lifted on a flat iron shovel; the door is then closed. The length of time required for burning the blocks on each slide varies according to the heat of the muffle; about fifteen minutes is allowed each slide. A too rapid heat tends to burn out or vaporize the colors of the enamels. The proper glazing of the teeth is ascertained by placing them under a gas jet.

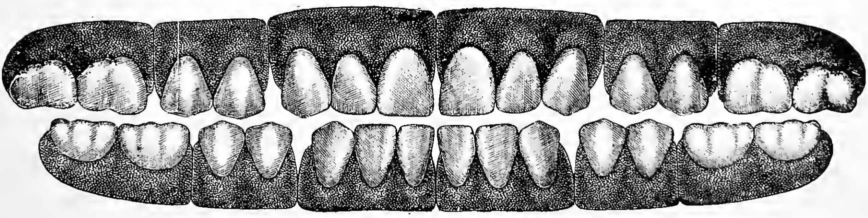
The appearance of this glaze is difficult to describe and must be seen to be appreciated; when once intelligently observed it will always be recognizable. When the final burning is satisfactorily accomplished, they are put in the cooling muffle, protected from the air by a door or stopper, and left undisturbed until quite cold.

CLASSES OF PORCELAIN TEETH.

Porcelain teeth may be divided into two general classes, namely, gum and plain teeth. In the former the labial or buccal portions of the gum about the teeth are represented by porcelain which is colored to imitate the mucous membrane, while the latter represent only the crowns of the teeth. The base upon which they are to be mounted and the means of attachment to the base further divide them into classes as follows:

- Gum teeth.
  - Gum section or block teeth (for vulcanite work) (Fig. 132).
  - Single gum teeth
    - Gum plate teeth (Figs. 133 and 134).
    - Single gum teeth (for vulcanite work) (Figs. 135 and 136).
- Plain teeth (single).
  - Plain rubber teeth (Fig. 137).
  - Countersunk pin teeth (Fig. 138).
  - Diatoric or pinless teeth (Figs. 139 and 140).
  - Plain plate teeth (Figs. 141, 142, 143, 144, and 145).
  - Saddle-back teeth (Figs. 146 and 147).
  - Continuous-gum teeth (Fig. 148).
  - English tube teeth (Figs. 149, 150, and 151).

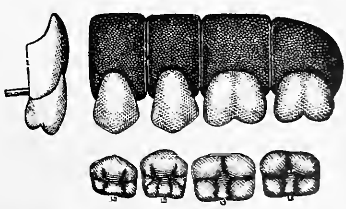
FIG. 132



Gum section teeth, upper and lower.

FIG. 133

FIG. 134



Single gum plate teeth.

FIG. 135

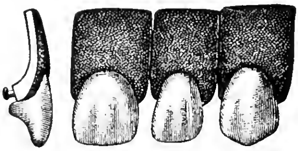
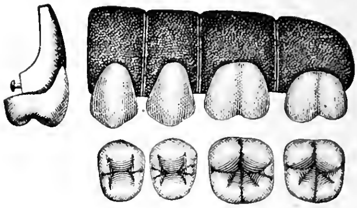
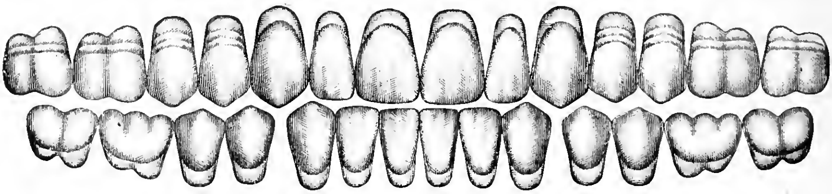


FIG. 136



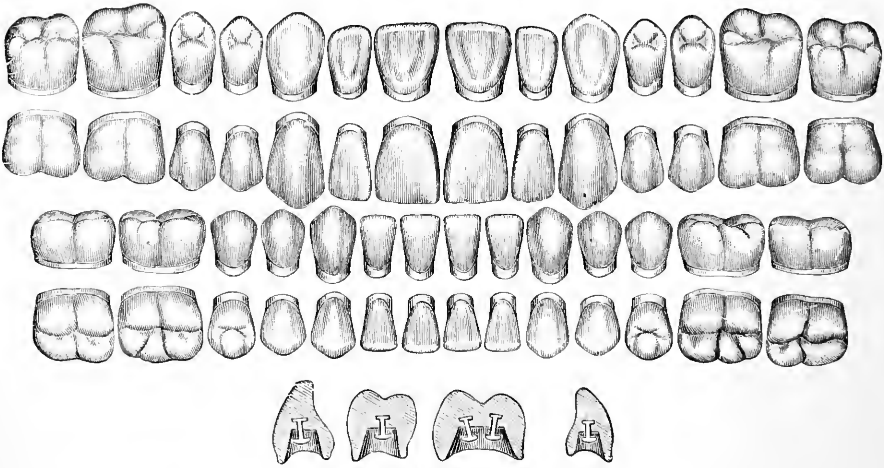
Single gum teeth for vulcanite work.

FIG. 137



Plain rubber teeth, upper and lower.

FIG. 138



Countersunk pin teeth

FIG. 139

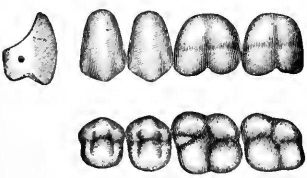
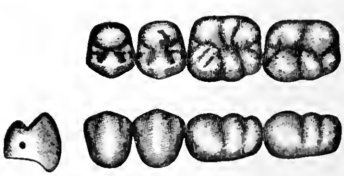


FIG. 140



Diatoric or pinless teeth, upper and lower molars and bicuspids.

FIG. 141

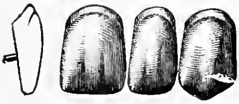


FIG. 142

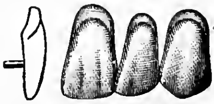


FIG. 143

Plain plate teeth, incisors and canines.

Fig. 144

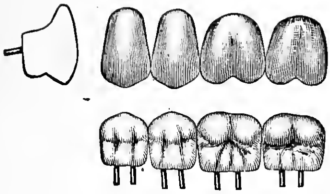
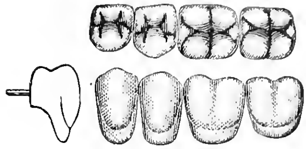


Fig. 145



Plain plate teeth, bicuspids and molars.

Fig. 146

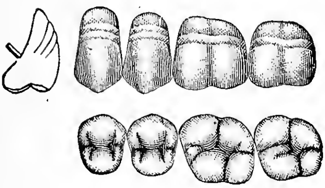
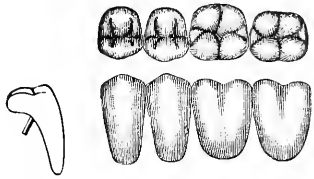
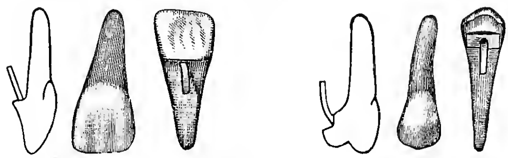


Fig. 147



Saddle-back teeth, upper and lower molars, and bicuspids

Fig. 148



Continuous-gum teeth, incisor and bicuspid.

Fig 149

Incisors.
Defective. Improved.

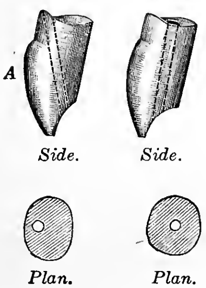


Fig. 150

Bicuspid.

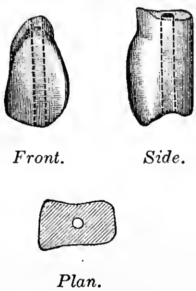
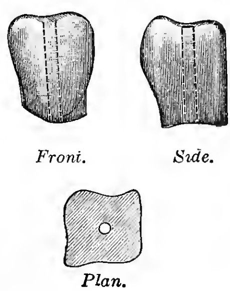


Fig. 151

Molar.



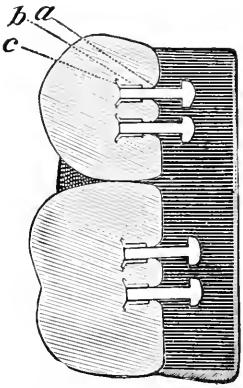
English tube teeth.

The means by which the porcelain teeth are attached to the base plate upon which they are mounted, is usually two platinum pins, the headed ends of which are embedded in the substance of the teeth and firmly fixed in it when the porcelain is baked. Platinum and porcelain have very nearly the same coefficient of expansion, so that in a similar range of temperature they approximately expand and contract alike, and there is small danger of a cracking of the tooth or a loosening

of the pin. It must be remembered, however, that the capacity for absorbing heat differs greatly with the two substances, platinum having a much higher specific heat, which fact, coupled with its greater conductivity, makes it necessary that a greater amount of heat should be applied to the porcelain when teeth are subjected to high heat. The platinum does not fuse at the high temperature necessary to the baking of the body of the tooth, and its non-oxidizable surface makes it possible for the porcelain to adhere to it with considerable tenacity. One manufacturer alloys iridium in small amount with the platinum to give the pins greater rigidity and tensile strength.

The great cost of platinum has been responsible for many attempts either to substitute other and less expensive metals for it, or to reduce the amount of metal used for the attachment in the tooth, or to dispense with the pins altogether. The less expensive metal usually employed is nickel or some of its alloys, but as these readily oxidize during the baking, the intimacy of the union between pin and tooth cannot be so close as where platinum is used. The discoloration of the tooth from the dissolved oxides of the pins is frequently sufficient in amount to be objectionable, and the low fusing body which is necessary with teeth of this sort is not so strong as that which may be baked on platinum pins. The attachment of pins of base metal to platinum anchorage baked in the tooth by soldering the pin to the anchorage is an ingenious method adopted by one manufacturer to reduce the amount of platinum (Fig. 152). The anchorage is in the form of a tube embedded in the porcelain, the inner end of which is expanded into a flange which is for firm retention. The pins of alloy are made to fit the tubes and are soldered to them with high grade solder, and tests seem to have proven that the teeth are strong enough for satisfactory service.

Fig. 152



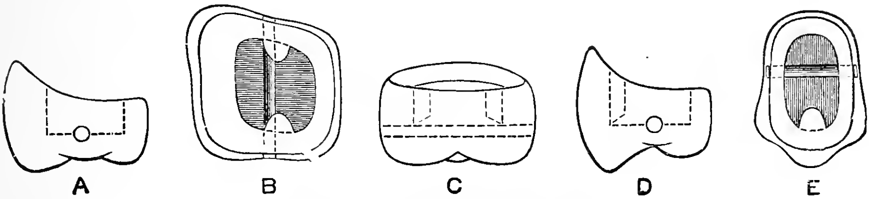
a, Base metal pin; *b*, platinum anchorage; *c*, expanded end of same.

The construction of teeth whose attachment is by means of an undercut recess in the tooth filled with the plastic base upon which they are mounted is another attempt to reduce the cost of production by doing away with the platinum entirely. They are called "pinless" or "diatoric teeth" (Fig. 153). The mechanical difficulties in the construction of a tooth of this type, which shall be sufficiently strong, have limited their use practically to the bicuspids and molars, in which positions under favorable conditions they are eminently satisfactory. It must be remembered that as their strength depends upon the bulk of porcelain composing them, and that as this is less than in pin teeth, it is not possible to make more than minor changes in them by grinding.

Gum teeth are made for metal plates and for the plastic bases, those for the former being at this time made only as single teeth (Figs. 133 and 134), while those for the latter are usually in sections of two or more teeth and designated "gum section" or "block" teeth (Figs. 132 and 154–

159). The use of gum teeth is limited to those cases in which resorption of the alveolar process has taken place to such an extent as to demand considerable restoration by means of the denture. With the exception of that found in continuous-gum dentures the porcelain of gum teeth provides the best imitation of the natural tissues which has been obtained, but the fixedness of the relation between the teeth in the sections, and the difficulty of joining, particularly of the single gum teeth, are drawbacks which this does not overbalance. The artistic possibilities in arrangement which plain teeth offer have caused them to come into general use, and in most cases they are to be preferred. It must be remembered, however, that in some full dentures, and many

Fig. 153



Plan of diatoric bicuspid and molar.

Fig. 154

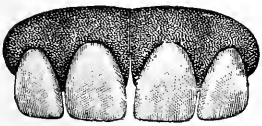


Fig. 155

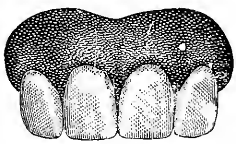


Fig. 156

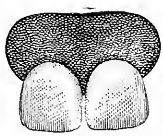


Fig. 157

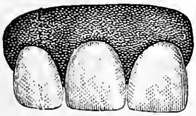


Fig. 158

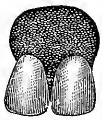
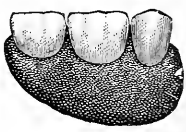


Fig. 159



Gum sections for partial cases.

partial ones, gum teeth may be used to great advantage. They are made in a variety of forms and offer a wide selection (Figs. 154 to 159).

The forms of porcelain teeth are determined by three factors. The most important of these is the anatomical characteristics of the teeth they are to substitute. As only the crown is represented, the labial or buccal surfaces, the morsal surfaces, and such portions of the approximal surfaces as are presented to view are patterned after the natural teeth. Teeth quite satisfactory in this respect are manufactured to-day, although the market contains many made according to old designs which are poor imitations of the natural organs. The form of the incisors and cuspids is in general much better than that of the molars and bicuspids, the occlusal surfaces of many of which are too narrow for the best masti-

catory results, the cusps are too poorly defined, and no attempt is made to have those of opposing sets fit together.

The shape of the other portions of the teeth is determined by considerations relative to their attachment to the base upon which they are mounted, and by the mechanical requirements which the shape and relation of the jaws impose. Teeth for vulcanite and celluloid work are similar in design (Figs. 160 to 169). When the latter came into use the artistic possibilities of the new material created a demand for more natural forms of teeth, and so-called "celluloid" teeth were designed

Fig. 160

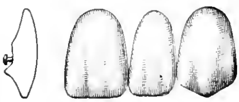


Fig. 161

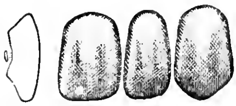


Fig. 162

Fig. 163

Fig. 164

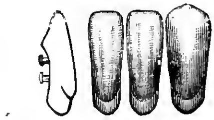


Fig. 165

Plain rubber teeth, upper and lower incisors, and cuspids.

Fig. 166

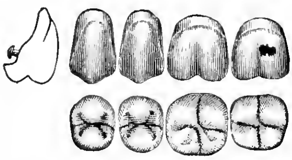


Fig. 167

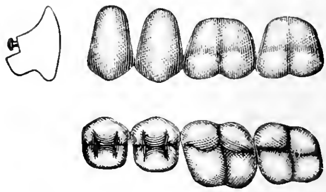


Fig. 168

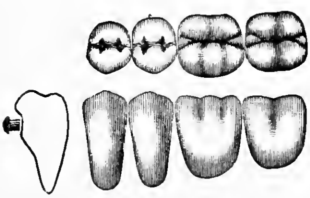
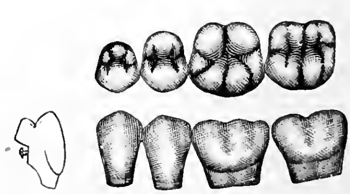


Fig. 169



Plain rubber teeth, upper and lower bicuspids, and molars.

to meet it. Teeth of this form may also be used with a cast-metal base, but they are all designated rubber teeth.

Plain rubber teeth are provided with two-headed pins to secure their attachment to the vulcanite. In the incisors and cuspids there is the so-called "pin" guard situated between the pins and the morsal edge to afford a shoulder to which the vulcanite may be finished.

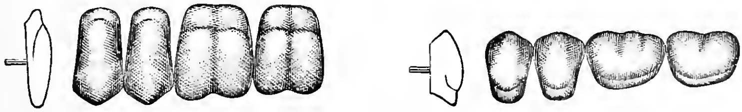
Countersunk pin teeth were introduced about 1885. Their lingual surface corresponds in shape to that of the natural teeth, the attachment to the molded base being by means of pins located in a depression in their base. Their close conformity in contour to the natural organs makes them more acceptable to the tongue than teeth backed in the ordinary way, and renders articulation easier and more distinct.

Inasmuch as they must be mounted almost over the alveolar ridge, they cannot be used in cases with a short bite.

Plain plate teeth are designed for use on a metal plate or in crown and bridge-work. The incisors and cuspids, in either instance, are similar in form (Figs. 137 to 139), but those for use in the bicuspid and molar region for crown and bridge-work represent only the buccal surface of the tooth, and are sometimes known as "veneers" (Fig. 170).

Two pins project from the flat back of the tooth to afford attachment to the metal backing which is brought into contact with the back of the tooth for its support. These pins are arranged crosswise in very short

Fig. 170



Veneers for crown and bridge-work.

teeth, but where there is space they are arranged longitudinally because of the greater strength thus obtained.

Saddle-back teeth (Figs. 146 and 147) are suitable for vulcanite dentures in which the space between the jaws posteriorly is very slight and where it would not be possible to get in a plain rubber tooth. They may also be used for bridge-work.

Continuous-gum teeth are illustrated in Fig. 148. It will be seen that they have only one long pin, and that the buccal and labial portions of their roots are represented in porcelain. This contributes to the firmness of their attachment to the base, the porcelain body fusing upon the roots and uniting them to the plate. It also maintains the contours of these regions by reducing the amount of porcelain body to be baked, and hence the contraction in this locality.

English tube teeth (Fig. 145 to 149) are little used in this country except for crowns, but they are more or less extensively employed in England. A platinum tube baked in the centre of the tooth affords lodgment for the pin which attaches them to the plate or root.

CHAPTER IV.

THE HUMAN DENTAL MECHANISM; ITS STRUCTURE, FUNCTIONS, AND RELATIONS.

By Charles R. Turner, D.D.S., M.D.

The oral cavity is situated at the beginning of the alimentary canal; it serves for the intake of food, and is provided with the means of its preparation for the subsequent stages of digestion and for assimilation. In the production of articulate speech, it serves as a resonating chamber for the vowel tones, and by alterations in its shape, through the action of the muscles of the tongue, lips, cheeks, and palate, it determines the character of the consonant sounds. The face is the principal seat of the expression of emotions in man, and as the mouth is one of its most mobile features, it participates prominently in the performance of this function. The loss of the teeth and the changes in the surrounding tissues which result therefrom are followed by an interference with the functions above enumerated, and by alterations of facial contour which greatly affect the personal appearance of their losers. As it is the purpose of dental prosthesis to prevent or remedy these changes, as far as possible, by the substitution of artificial apparatus for the lost tissues, a knowledge of the normal operation of the several functions thus affected is of fundamental importance to the study of the subject. This chapter aims, therefore, to treat of the functions of the dental mechanism from this point of view. It will discuss the manner in which they are affected by the loss of the teeth, so that the problems arising in tooth replacement may be solved the more satisfactorily.

The most important function of the mouth, from the standpoint of the body economy, is the preparation of food for the subsequent stages of digestion. Food stuffs of various degrees of physical consistence are introduced into the cavity, their solid portions are cut, crushed or ground, mixed with the saliva, and are then carried into the stomach. As this is largely a mechanical process, we shall first take an analytical view of the mechanism by which it is accomplished.

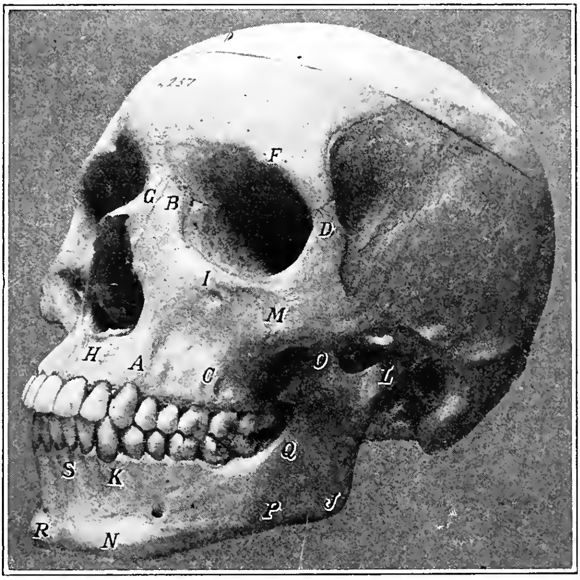
THE HUMAN DENTAL MECHANISM.

Architecturally considered, the masticating mechanism consists of a fixed base, the upper jaw, supporting the upper teeth, against which is operated a movable arm, the lower jaw, also equipped with teeth so placed as to oppose those of the upper jaw. The teeth serve as the armament of the apparatus, affording hard surfaces between which the food is crushed. Muscles extending between the fixed and movable elements of the apparatus, and so disposed as to be capable of exerting

great pressure in approximating them, furnish the active forces of the mechanism; while the walls of the buccal cavity, which contains the apparatus, serve to confine the food, and the lips and cheeks together with the tongue further assist the process by keeping it between the crushing surfaces.

The Fixed Base.—The axial skeleton of the body consists of the vertebral column, the skeletal basis of the trunk, which supports upon its upper extremity, the skull. The cranial portion of the skull receives direct support at the atlo-occipital articulation, the facial portion being in turn suspended from the anterior surface of the cranium. The superior maxillæ, united in the median line and lodging the upper teeth, are supported upon the cranium through articulations by the frontal, lachrymal, ethmoid, palate, vomer, and malar bones, and constitute the fixed base of the masticating mechanism.

Fig. 171

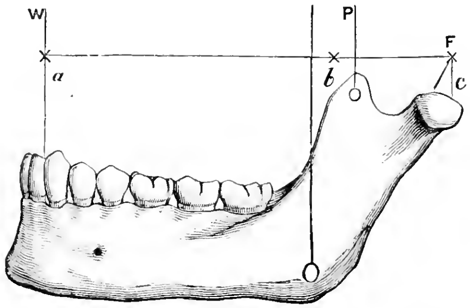


Architectural construction of skeletal portion of masticating apparatus: the fixed base, and moveable arm, Columns, arches, and buttresses of the fixed base; fronto-nasal column, A B; zygomatic column, C M D; pterygoid column (only partly visible), supra-orbital arch, B F D; infra-orbital arch, B I D; upper nasal half arch, B G; palatal arch (not shown); lower nasal arch, A H; large molar arch, A C; molar buttresses (descending from M); pterygoid arches (not shown). Columns and arches of the moveable arm; mental column, N K; coronoid column, P Q O; and condyloid column, J L; external oblique column, Q N. (From a photograph of specimen No, 4237, Wistar Institute of Anatomy.)

The arch shaped alveolar process (Fig. 171), containing the teeth which receive the impact of mastication, is supported upon the cranium by three pairs of columns or buttresses, reinforced by several secondary arches and braces. (Burchard.) The columns are the fronto-nasal, ascending from the position of the canine tooth to the inner margin of the orbit, and reaching the frontal bone; the zygomatic, extending from

the position of the first molar tooth through the outer margin of the orbit; and the pterygoid, ascending from the molar region upward and backward to the sphenoid. These columns are strengthened by braces as follows: the supra-orbital arch, the infra-orbital arch, the upper nasal half arches, the palatal arch, the lower nasal half arches, the large molar arch, the molar buttresses, and the pterygoid arches. It will be noted that the articulations of the maxillæ, notably those with the malar bones, are disposed to resist stress operating from below. This fixed base is admirably constructed to receive, resist and dissipate force received from below so that the brain and delicate sense organs contained in the face will not be unduly shocked during mastication, and is "erected to endure the shock of impact from all sorts of biting, *i. e.*, cutting, tearing, crushing, triturating with longitudinal and transverse motions, and to resist and stand firm during all the varieties of movements incident to mastication."

FIG. 172



The lower jaw as a lever of the third class. (Burchard.)

The Movable Arm.—The lower jaw consists of an arch-shaped horizontal portion, the body, which supports the lower teeth by means of its alveolar process, and terminates posteriorly in two vertical branches, the rami, by which it articulates with the cranium. It may be regarded mechanically as a lever of the third class (Fig. 172), the fulcrum being located at the temporo-mandibular joint, the power being represented by the levator muscles, while the weight consists in the resistance to the elevation of the jaw offered by the food between the teeth.

The muscular apparatus by which the jaw is raised is attached in part to the cranium and in part to the strong zygomatic arch, and is not concentrated upon one point on the mandible, but its attachment thereto is distributed between the fulcrum and the weight. The resultant line of its action when the teeth are in contact passes slightly behind the coronoid process of the mandible and approximately through its anatomical angle. (Fig. 173, M.) The lever is bent at this point so that the general plane of the teeth when in occlusion is perpendicular to the line of action of the levators. By this arrangement the teeth may best oppose the action of the levators, since they resist force best which acts

at a right angle with the general plane of their occlusal surfaces. The resistance offered by the food between the teeth (which represents the weight) varies for any given food with its position on the teeth. For a food of given resistance the farther back in the mouth it is placed, the nearer it is to the fulcrum, and the shorter the weight-arm of the lever, and hence the less will be the muscular force necessary to overcome the resistance.

The point of the origin and insertion of the muscles is fixed, but as the position of the fulcrum changes in its relation to the former of these during the movements of the jaw, the length of the power-arm of the lever is affected, and the resistance which may be overcome by the muscles varies in accordance therewith. The more nearly the jaws are together

Fig. 173

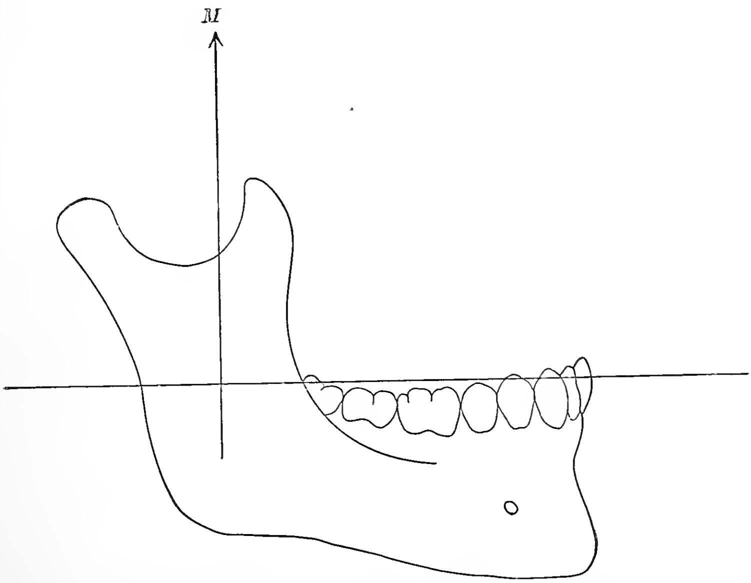


Diagram illustrating line of action of levators of lower jaw.

the longer is the power-arm, and hence it will be found that the more nearly they are approximated, the greater will be the power which the muscles may exert. From these several facts it will be seen that the lever is of the type best suited to the lifting of a heavy weight slowly through a short distance.

To resist the stress put upon it in these operations the jaw is well designed structurally. (Fig. 171.) It may be considered as composed of several pairs of bony columns. The vertical columns are the mental column, extending perpendicularly upward from the lower margin of the body to the position of the canine tooth, the coronoid, ending in the coronoid process, and the condyloid parallel to it and ending in the condyle. These are bound together by the long body columns of the

external and internal oblique lines. Cryer[1] has pointed out the architectural strength of the body of the bone, the cortical U-shaped portion of the exterior being bound together by the internal cancellated tissue.

The fulcrum of the lever rests upon the base of the skull where the bone is thick and dense and well designed to resist the force put upon it, and the joint itself is provided with intervening soft tissues as a means of lessening the shock of activity.

The Temporo-Mandibular Articulation.—This is a condylarthrodial joint, the structures taking part in it being the glenoid fossa of the temporal bone and the condyle of the lower jaw, together with the proper and accessory ligaments, and the tissues interposed between the bones.

The Glenoid Fossa.—This is an oblong cavity (Fig. 174) on the under

FIG. 174

Left glenoid fossæ of four skulls, showing differences in form.

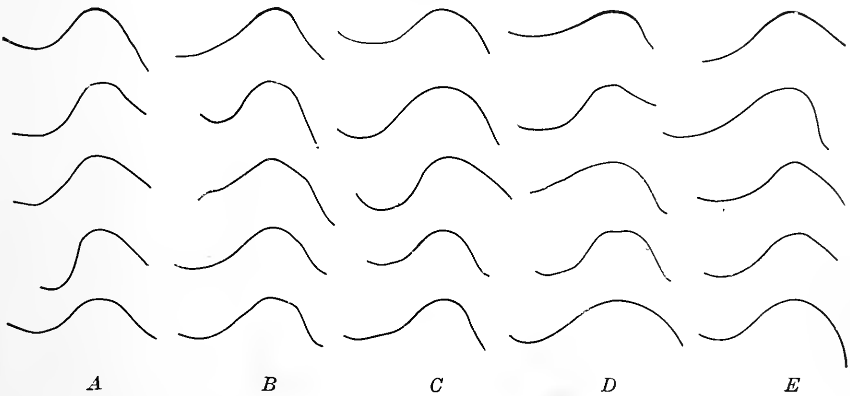
surface of the squamous portion of the temporal bone, its concavity being directed downward. It is bounded anteriorly, by the eminentia articularis (the anterior root of the zygoma), externally, by the middle root of the zygoma and the auditory process, and posteriorly, by the tympanic plate of the petrous portion of this bone. The Glaserian fissure which runs across the cavity divides it into two unequal portions, the posterior third being rough and lodging a portion of the parotid gland, the anterior two-thirds being smooth and covered in the recent state with a dense fibrous tissue and receiving the condyle of the lower jaw. Of the articular portion of the fossa the distal part is the most concave and is also the most elevated. From this point it slopes downward and forward to the crest of the eminentia articularis, furnishing a surface over which the condyle glides in the forward excursions of the mandible. The shape of the cavity varies with different nationalities, with different individuals, and sometimes on both sides of the same individual. The principal variations are (1) in size and general concavity, in correspondence with the shape of the condyle; (2) in extent of surface from the most concave portion to the eminentia articularis; (3) in its inclination.

[1] Internal Anatomy of the Face.

The outlines in Fig. 175 show the curve of this cavity obtained from skulls after the method of Tomes and Dolamore. The fossa alters frequently in old age from the pull of the muscles upon the mandible in trying to bring into occlusion teeth that may be widely separated in location.

The condyle of the lower jaw (Fig. 176), is the upper extremity of the ramus which fits into the glenoid fossa. It consists of the neck by which it is joined to the ramus, and the head which is ovoid and oblong in shape corresponding to the fossa into which it fits. Its long axis is transverse, and if extended would meet that of the other condyle approximately in front of the foramen magnum, while its short axis prolonged would meet that of its fellow approximately at the symphysis mentis. It is convex from before backward and from side to side. The articular surface extends to a lower level posteriorly than

Fig. 175



Outlines of glenoid fossæ obtained by the method of Tomes and Dolamore. The heavy base line is parallel to a line drawn from the anterior nasal spine to the floor of the external auditory meatus. All the fossæ outlined were on the left side of the skull. A, from skulls with typical dentures; B and C from skulls with several teeth missing; D and E, from edentulous skulls.

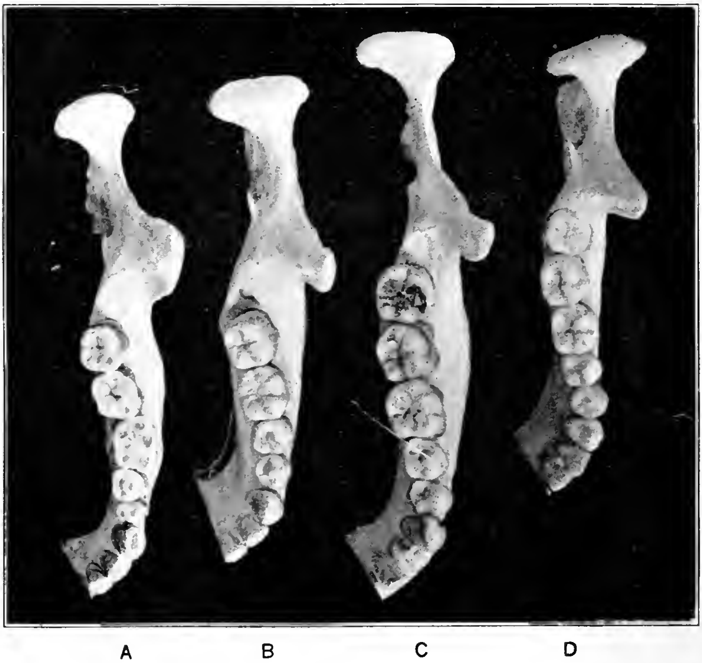
anteriorly to permit rotation of the jaw about the condyles. The articular surface of the condyle may be said to present two faces, an upper or anterior and a lower or posterior, the division between them not being distinctly marked. It is covered with a thin covering of fibrous tissue which serves to even up its surface without altering its shape.

The shape of the condyle and the fossa, which more or less accurately correspond in size, differs greatly in different individuals. There is a definite relation between the shape of these parts and the movement of which the lower jaw is capable. The long narrow condyle (Fig. 176, D), characteristic of the nervous temperament, is received into a groove-like fossa, and permits more easily the up and down motion of the jaw, in which the joint acts largely as a hinge. In the sanguine temperament (Fig. 176, B), the condyle is more rounded, the articulation partak-

ing more of the nature of a ball-and-socket-joint, the lateral excursion of the mandible being readily accomplished. In the bilious temperament the condyle (Fig. 176, C) is also narrow and long, while in the lymphatic (Fig. 176, A), the joint favors greatly lateral movement and the condyle and fossa are flattened correspondingly.

Interposed between the head of the condyle and the fossa and separated from each by a synovial sac is found the interarticular fibro-cartilage (Fig. 177). This is a disk-like cartilage ovoid in shape, its upper surface concavo-convex from before backward to correspond to the shape of the fossa. It is concave in front where it comes in contact with the eminentia articularis, and convex posteriorly where it fits into the concavity of the fossa. On its lower surface

FIG. 176

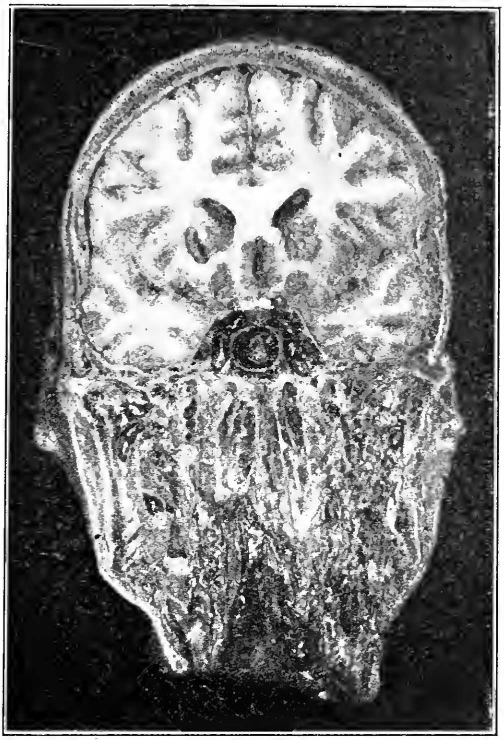


Left condyles of four mandibles, showing differences in form: A, partaking of the characteristics of the lymphatic temperament; B, partaking of the characteristics of the sanguine temperament; C, partaking of the characteristics of the bilious temperament; D, partaking of the characteristics of the nervous temperament.

it is concave. The posterior border is nearly twice as thick as the anterior, while the external border is thicker than the internal. In the normal resting bite the cartilage covers only the upper anterior portion and the top of the condyle which it surmounts, while the posterior aspect of the articular surface of the condyle is not in contact with it, but with the posterior part of the capsule. In the excursion of the jaw the cartilage and condyle leave the fossa together or more rarely

the condyle goes forward over the surface of the cartilage. The disk is attached to the condyle most intimately internally and externally, which causes the cartilage and condyle to go forward together and

FIG. 177



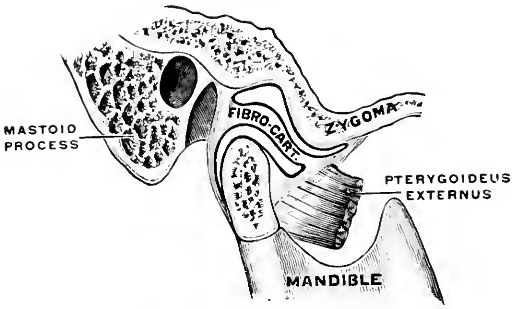
Vertical section through head passing through both temporo-mandibular articulations and showing on the left side of illustration, the right condyle, cartilage, and fossa. Looking backward. (Cryer.)

yet does not prevent a rotation of the jaw about the condyles. The contraction of the external pterygoid muscle, which is attached to the anterior edge of the cartilage, is equally responsible for its forward movement. The synovial sacs (Fig. 178) above and below the disk, permit the gliding and rotating movements of the joint. The cartilage always furnishes a base upon which rotation takes place and is always interposed between the condyle and the fossa.

The ligaments of the joint (Figs. 179 and 180), are the capsular, the external and internal lateral ligaments, which are only thickenings of the capsular, and several accessory ligaments.

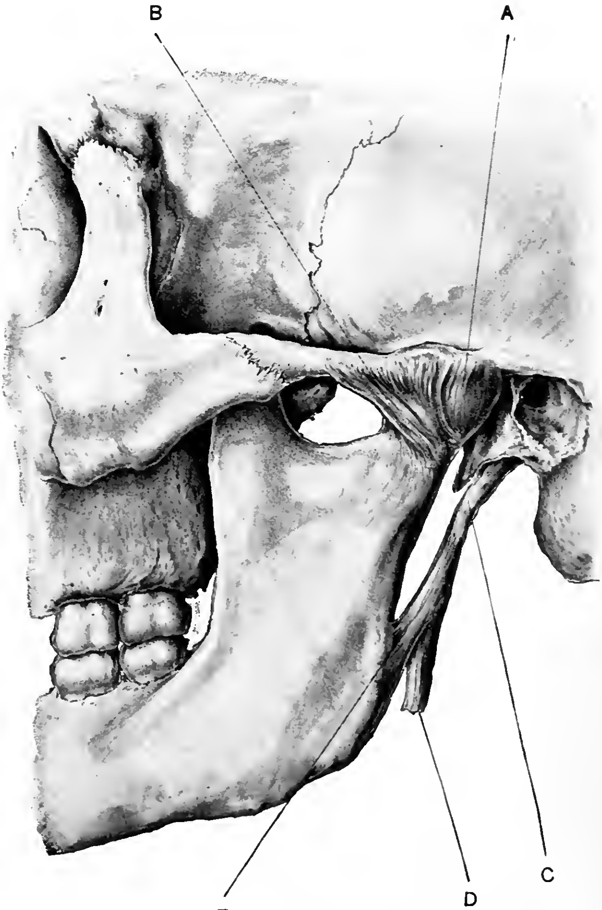
The capsular ligament is attached above to the anterior border of the root of the zygoma, behind to the bottom of the glenoid cavity a little in front of the Glaserian fissure, on the outside to the zygomatic tubercle and the longitudinal root which follows it, and on the inside to the base of the spine of the sphenoid. It is attached below around

Fig. 178



Temporo-mandibular articulation in sagittal sections. (Testut.)

Fig. 179

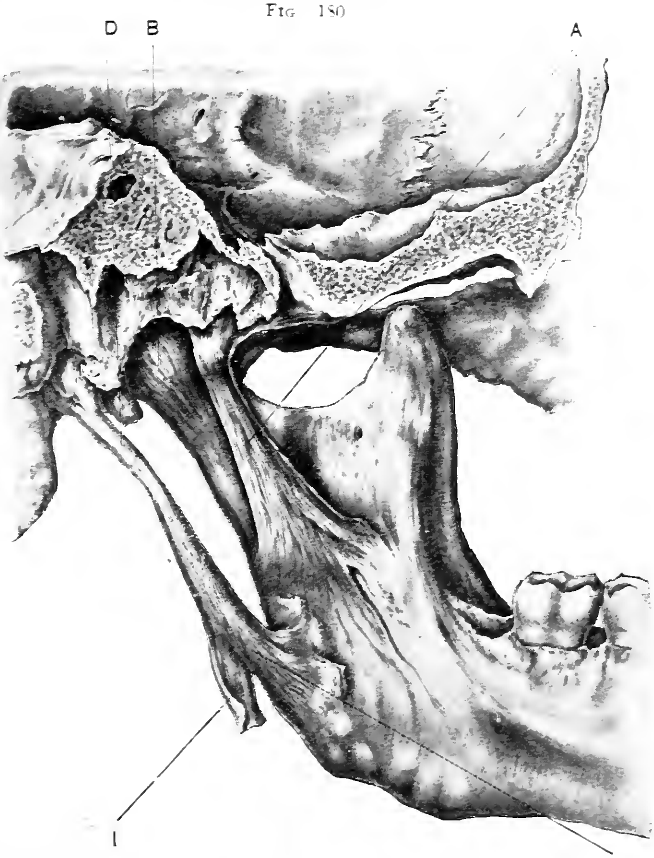


Ligaments of temporo-mandibular joint: (external view). A, capsular; B, external lateral; C, stylo-maxillary. (Deaver.)

the neck of the condyle: anteriorly, immediately below the articular surface, posteriorly, to a line 3–4 mm. lower. This permits the articular surface of the condyle to be in relation with the cartilage during any of its normal movements. The internal surface of the capsular ligament is intimately connected with the cartilage around its periphery where the two come in contact, thus dividing the cavity into two portions.

The capsular ligament consists mainly of vertical fibers, and is thin, particularly in front, where it gives attachment to some fibers of the

FIG. 180



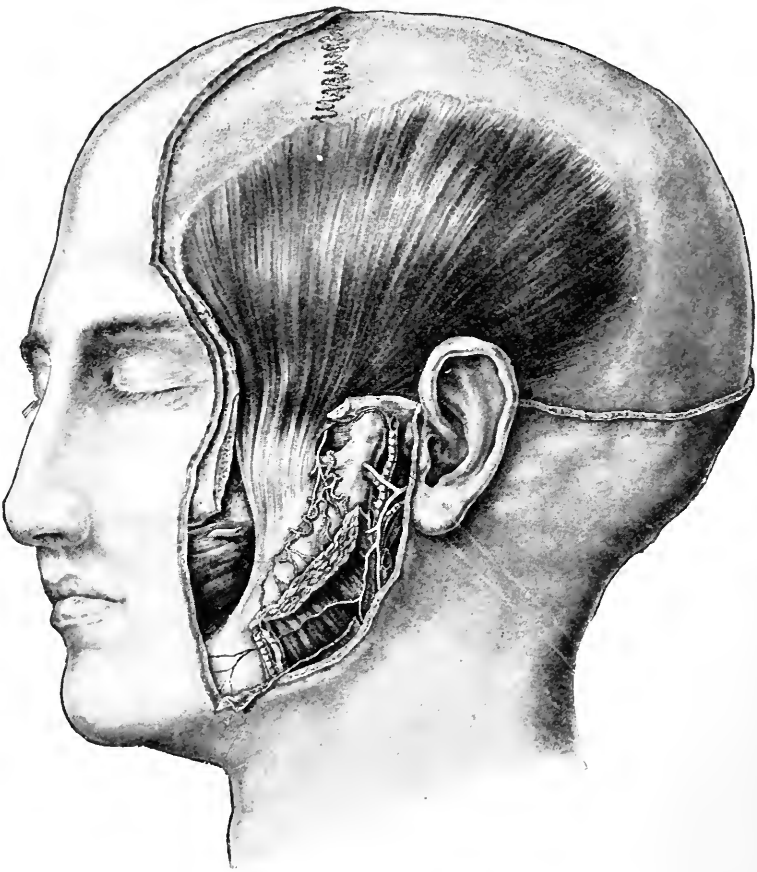
Ligaments of the temporo-mandibular joint (internal view): A, Long internal lateral or spheno-maxillary; B, short internal lateral; C, stylo-maxillary. (Deaver.)

external pterygoid muscle. Posteriorly there are some elastic fibres attached a little anterior to the Glaserian fissure, and passing downward are attached to the cartilage and the neck. Sappey[1] says these contribute to limit the forward displacement of the cartilage and condyle and serve to bring the former back when the mandible retreats into the fossa.

[1] Traité D'anatomie Humaine. Testut.

The principal suspensory ligament is the external lateral, which is attached above to the outer surface of the zygoma and to the rough tubercle on its lower border, and below to the outer surface and posterior border of the neck of the condyle. It is a stout thick ligament, broader above than below, its anterior fibres being the longer, and anterior to the horizontal axis of the condyle. By reason of its attachment it assists in compelling a forward movement of the condyle during depression of the jaw.

FIG. 181



Temporal muscle. (Deaver.)

The internal lateral (or short internal lateral), is shorter than the external, is inserted into the back of the neck of the condyle, and has longer outer fibres.

The spheno-maxillary (or long internal lateral ligament) is attached to the alar spine of the sphenoid and extends to the spine on the mandible internal to the inferior dental foramen.

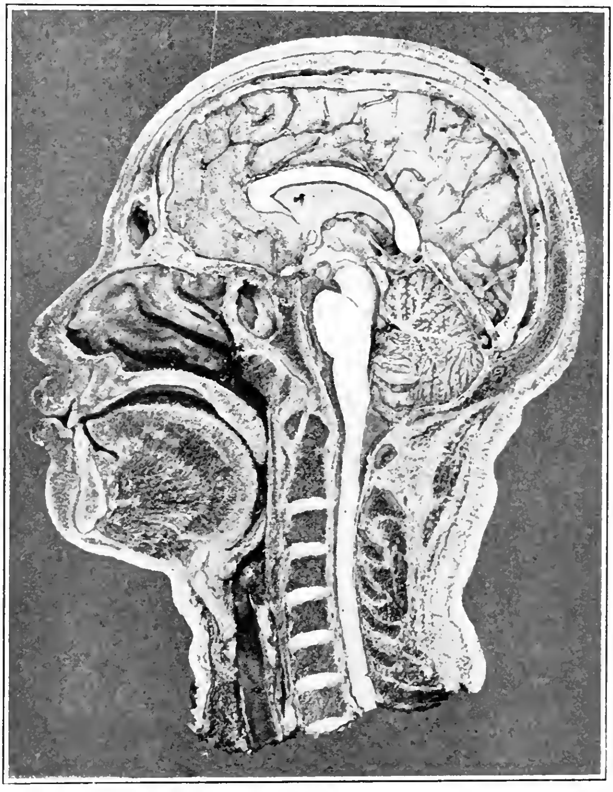
The stylo-maxillary is a specialized band of cervical fascia, extending from the styloid process to the ramus a little above the angle of the jaw. This also assists in compelling a forward movement of the condyle in depression of the jaw.

It will be noted that the ligaments of the joint, while permitting great freedom of movement in certain directions, bind the condyle firmly in the fossa, and that the groove-like character of the socket limits its movement in certain directions. Movement distally is resisted by the posterior wall of the cavity, the extent of compressibility of the intervening soft tissues being the limit of movement in this direction. Movement forward is permitted, as we have seen. Movement outward is impossible and movement of the condyle inward is possible only to the extent permitted in rotation of the jaw about the other condyle. Any force tending to separate the contact between the condyle, cartilage, and fossa is resisted by the joint ligaments proper, notably the external lateral, so that such movement is permitted only to the amount to which these ligaments may be stretched. For all practical purposes the condyle and fossa may be said to be always in contact through the medium of the interposed cartilage, for the reason that the usual forces operating upon the jaw tend to press the condyle into the fossa and not to separate them. In edentulous patients where the fossæ are very flat, the ligaments seem to become lengthened, thus permitting a large range of movement to the jaw. The soft tissues interposed between the bones are slightly compressible, but this factor is so small in amount as to be practically negligible in estimating the path of the condyle during the movements of the jaw. Therefore within the restriction offered by the ligaments, this path will be determined, so far as the joint is concerned, almost solely by the form of the glenoid fossa. Hence it will be seen that there is a definite relationship between the movements of which the lower jaw is capable and the character of the temporo-mandibular articulation.

The Muscles.—The muscles attached to the lower jaw and producing its movements are the temporal, masseter, external and internal pterygoids, ordinarily classed as the muscles of mastication because they are the active forces in this process, together with the mylo-hyoid, the genio-hyoid, the digastric and the platysma myoides. With the exception of the last they are arranged in symmetrical pairs usually operating simultaneously in the principal movements of the jaw, although each is capable of independent contraction. The temporal muscle (Fig. 181), the principal levator of the mandible, arises from the whole of the temporal ridge and fossa and converges to be inserted into the coronoid process. The masseter, short, quadrilateral, thick, and powerful has two planes of fibres, the external, arising from the malar process of the superior maxilla, the outer surface and anterior two thirds of the zygoma, and inserted into the lower half of the ramus and the angle of the jaw; the internal layer, arising from posterior third of the zygoma and attached to the upper portion of the ramus. The internal pterygoid is also thick and quadrangular in shape, extending from the ptery-

goid fossa, its origin, to the inner surface of the ramus and the angle of the jaw. The external pterygoid arises by two heads, one from the under surface of the great wing of the sphenoid, the other from the tuberosity of the maxillary bone and the palate bone. The fibres pass almost horizontally backward and outward to be inserted into the neck of the condyle and the anterior margin of the inter-articular fibro-cartilage. With the exception of the last described muscle it will be seen from their points of attachment that they serve

Fig. 182



Median sagittal section of head, showing relation of structures in oral cavity when the mouth is closed. (Cryer.)

largely to elevate the mandible into contact with the maxillæ by rotating it about the condyle. They arise either from the cranium or from the strong zygomatic arch, and are attached to the lower jaw at points between the temporo-mandibular articulation and the teeth. They are short and powerful, and capable of exerting considerable force. The function of the external pterygoids acting together is to pull the condyle forward and downward over the surface of the glenoid fossa, and to so adjust the cartilage that it is always interposed between the condyle and the fossa. The external pterygoid on either side contracting

independently of its fellow, serves to pull its condyle downward, forward and inward, thus rotating the jaw about the opposite condyle.

The depressor muscles are mainly attached to the forward end of the mandible. The genio-hyoid and the anterior belly of the digastric are inserted into its inner surface near the median line; the mylo-hyoid being attached to the ridge of that name. They operate from the hyoid bone, which must first be fixed by the omo-hyoid, sterno-hyoid, and thyro-hyoid muscles. The platysma myoides is attached below to the sternum and clavicle as its fixed base.

Under ordinary conditions when the mouth is closed (Fig. 182), the muscles are in repose and there is an absence of any active contraction on their part. The mandible is maintained in position partly by the tonicity of the levators, their length, however, in an ordinary state being too great to keep the jaws in contact. This is assisted by the influence of a certain negative intra-oral air-pressure amounting to about 2–4 mm. of mercury (Donders) which "is formed by the contraction of the muscles of the tongue and by the sinking of the mandible. The closed space arises from the closure of the lips, and the placing of the soft palate upon the root of the tongue."[1] The teeth are usually in contact at some point, the tongue practically fills the cavity of the mouth, the lips and the cheeks are closely applied to the teeth and alveolar process. This position is commonly termed "the resting bite." In it the teeth do not fit tightly together, the cusps not being closely received into their corresponding depressions, the condyles are distally placed in their fossæ, and the levators exhibit only ordinary tone.

If the levator muscles are contracted slightly, the jaw is drawn upward and backward to a position where the cusps and depressions of the teeth do correspond and we have a more closely fitting occlusion. At the same time the condyles are occupying their most distal position in the fossæ and we have what is called "the position of occlusion."

If the levators are still further contracted there is no closer fitting together of the teeth, but they are forced very slightly up into their sockets, a movement permitted by the elasticity of the pericementum, while at the same time the interarticular cartilage and other soft tissues intervening at the joint are likewise compressed slightly. It is the latitude of movement between the position of occlusion and this position which reduces the shock of the impact of the mandible during mastication.

The Movements of the Mandible.—Because of the fact that it has two articulations, the movements of the lower jaw are so complex that it will be best for our purposes to describe the simple movements, and then to see how they may be combined to produce the more complicated ones. Therefore those will be first discussed in which the symphysis of the jaw is moved in the sagittal plane of the body, or in other words, movements which are bilaterally symmetrical.

Depression.—This is produced by the weight of the jaw and by the action of the mylo-hyoid, genio-hyoid, anterior belly of digastric, and

[1] E. Herbst: Deutschen Zahnarztlichen Wochenschrift.

the platysma myoides muscles, which serve to depress the forward end of the jaw, and by the action of the external pterygoid muscles which pull the heads of the condyles downward and forward. The jaw rotates about a horizontal axis passing through the condyles which at the same time are being moved downward and forward. Sliding is thus combined with rotation through the whole movement of depression of jaw. (Fig. 183).

FIG. 183

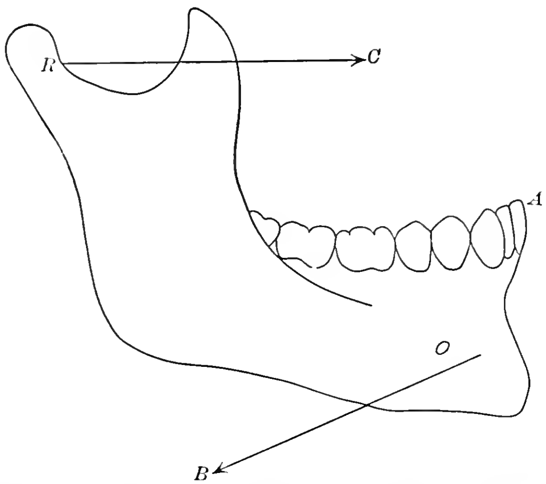


Diagram illustrating the direction of operation of the muscles in depressing the mandible R C, line of traction of external pterygoid muscles; O B, line of traction of mylo-hyoid, genio-hyoid and digastric muscles. (After Constant.)

The forward movement of the condyle is rendered necessary by the attachment of the external lateral ligament, which is so located as to compel a forward movement of the condyle when force tending to displace the jaw downward is applied at its anterior portion. It is also produced by the contraction of the external pterygoid muscle which likewise pulls forward the cartilage which surmounts it. Man's erect posture and the forward projection of the larynx necessitate this. The path which the condyle pursues, downward and forward, in this movement is dependent upon the shape of the glenoid fossa. Walker[1] found it to make "an angle ranging from 25° to 45° to the line or plane of occlusion, being from 30° to 50° to the facial line," the average of the former being 35°, but states that it varies very much even on both sides of the same individual.

In the extreme position of depression of which the jaw is capable the condyle is in the lowest and most anterior position which it ever assumes. While "the mandible describes approximately the arc of a circle" in this movement, "no portion of the actual path is coincident with the arc of a circle described from, as its centre, any position ever

[1] The Dental Cosmos. Vol. xxxviii., p. 34.

attained by the condyle."[1] The centre is generally from 1 to 1½ inch below the level of the condyle. The radius of the circle described by the morsal edges of the lower incisor teeth may vary from 4½ inches in length to 7 or 8, the centre being therefore usually behind the condyle.[2]

Elevation.—The simplest form which this movement may take is that which is the reverse of the one just described, the jaw pursuing the movement of depression in reverse order. The temporal, masseter, and internal pterygoid contract, serving to rotate the jaw about a horizontal axis passing through the condyles. The shape of the glenoid fossæ

FIG. 184

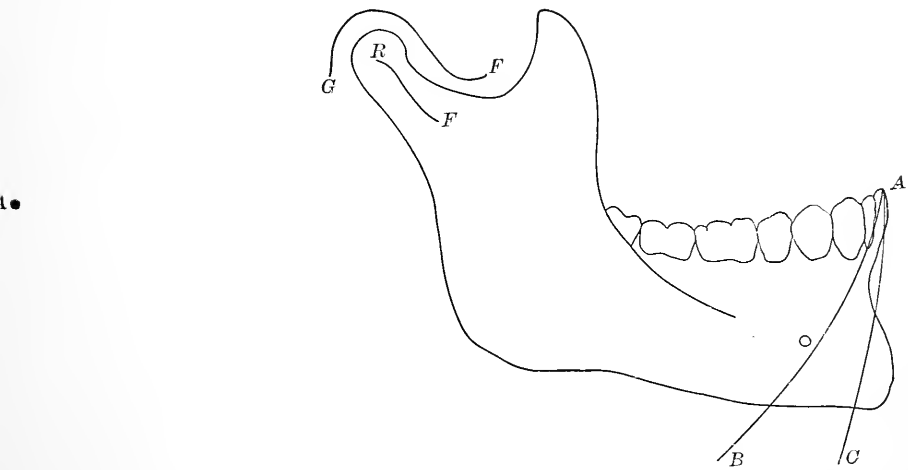


Diagram illustrating the path pursued by the mandible in depression. G. F, glenoid fossa; R, centre of condyle; R F, path pursued by centre of condyle; A, cutting edge of lower central incisors; A B, path which would be described by A if the mandible rotated about R and condyle remained in fossa; A C, actual path pursued by A in depression of the mandible; A, approximate centre of rotation for path A C actually pursued by the point A.

being such as to guide the condyles backward, they recede, the posterior elastic fibres of the capsule likewise carrying the cartilage back. In moving from the position of extreme depression, the contraction of the levators produces rotation about the condyles, the temporal muscle being most advantageously situated for this action. The stylo-maxillary ligaments, from their point of attachment, serve in the beginning to cause a distal movement of the condyles as rotation takes place. As elevation proceeds, this is contributed to by the external lateral ligaments and by the posterior fibres of the capsular ligament, while the upward inclination of the fossæ serves to guide the condyles upward and backward. For the jaw to pursue this path there must be full and complete relaxation of the external pterygoids, or the condyles will not move backward. After a certain point has been reached, these muscles have the power

[1] Tomes and Dolamore. Transactions Odontological Society of Great Britan, 1900, p. 167.
[2] Loc. cit.

of fixing the condyles on their return path to the distal part of the glenoid fossæ, and then elevation consists in a rotation of the jaw about them in this position. If they do not relax, or if there is contraction of the protrusor fibres of some of the levator muscles, the elevation may have combined with it some of the movement of protrusion. Tomes and Dolamore[1] found that in normal closure of the jaw the path of its anterior end is almost constantly anterior to that of opening. It is possible for the mandible to move from its most depressed position to that of occlusion, to that of extreme protrusion, or to any position between these, by paths, which depend in their character upon the proportion of protrusive movement combined with the elevation.

Protrusion—When the natural teeth are in occlusion the jaw cannot be carried forward until it has been slightly depressed to disengage the cusps. In an edentulous mouth however this does not obtain. The jaw is moved forward by the action of the external pterygoids contracting simultaneously, assisted by the external fibres of the masseter and the anterior fibres of the temporal and some fibres of the internal pterygoid (Constant). The external pterygoid also pulls forward the interarticular cartilage, this movement however being also due to the intimacy of its attachment to the condyle by means of the capsular ligament. The condyles move downward and forward, thus depressing the distal portion of the lower jaw on the average about $\frac{1}{8}$ of an inch, a fact brought out by Balkwill[2] and later by Walker[3] and several investigators since him, the amount of the depression being determined by the inclination of the glenoid fossa and differing vastly in different individuals. In the most forward position assumed by the jaw in protrusion, the condyle is nearly upon the eminentia articularis. This, however, is not as far forward as in the position of greatest depression, for in addition to the joint ligaments proper, the stylo-maxillary, and other tissues attached to the back of the ramus are put on the stretch and prevent the forward movement of the condyle, unless it is rotated forward as occurs in depression of the mandible.

Retraction.—This is the reverse of the movement of protrusion, and the jaw may be brought back along the same path which it pursued in the forward movement. This is produced by the contraction of the posterior fibres of the temporal, the internal portion of the masseter, the digastric, the genio-hyoid and mylo-hyoid muscles. The condyle is carried backward and upward, the cartilage accompanying it. There may be combined with this various amounts of depression, as for instance, the jaw may move from its most protruded position back to that of occlusion, or to its most depressed position, or to any point or along any path intervening between the two. In moving from the most protruded to the most depressed position, the stylo-maxillary and the posterior fibres of the capsular ligament being on the stretch, cause the condyle to be moved forward and downward.

[1] Loc. cit.

[2] Transactions of Odontological Society of Great Britain Vol. v., p. 133.

[3] The Dental Cosmos. Vol. xxxviii., p, 34.

Combinations of these two kinds of movements may occur in various amounts. Thus far we have considered the movements which the lower jaw may make by simultaneous and equalized contraction of the muscles of both sides.

Lateral Movements.—The lateral excursions of the mandible are made possible by the sliding character of the temporo-mandibular joint and the fact that protrusion may occur independently on either side. The external pterygoid muscle does not operate in a plane identical with or parallel to that in which the condyle moves in its forward

Fig. 185

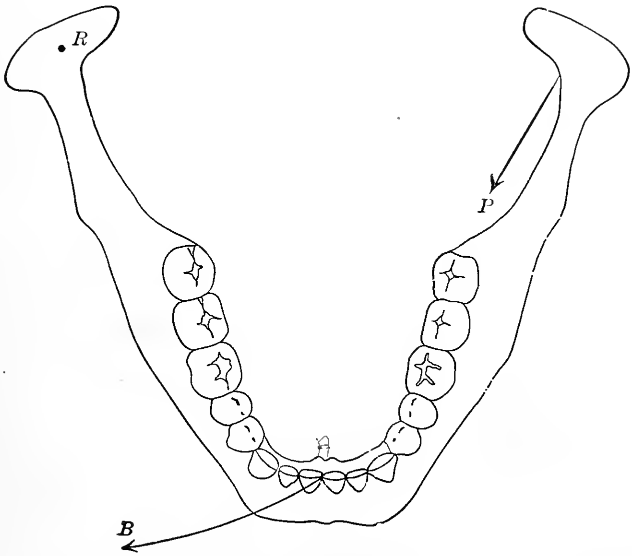


Diagram illustrating action of external pterygoid muscle. R, stationary centre of rotation in right condyle; P, line of action of left pterygoid; A B, path pursued by point A on contraction of left external pterygoid.

excursion. Its action is to pull the condyle inward as well as forward and it is only by the simultaneous contraction of both that the jaw is bodily protruded. (Fig. 185.) Acting singly, therefore, when the condyle on the opposite side is held in the fossa, its influence is to draw the condyle inward, forward and downward over the inclined floor of the fossa, causing a rotation of the mandible about a vertical axis passing through the opposite condyle. In this movement the path of the condyle (Fig. 186), is approximately in the arc of a circle upon the floor of the fossa, and it may be carried no farther forward, if indeed, as far as in the movement of protrusion. The simplest form of the return movement is for the condyle to pursue the same path back to its distal position in the fossa. When the jaw is carried to the other side in its lateral excursion, the opposite condyle in turn is pulled downward and forward, and the jaw rotates about the other.

This movement may be combined with that of depression of the jaw as above described. In this event the lateral movement simply seems to make an alteration in the position of the horizontal axis about which the rotation element of the movement of depression takes place. The greater the forward pull on one condyle as related to the other, and hence the greater the lateral movement, the less depression may be combined with it, and as the depression increases the lateral movement must of necessity decrease. We have seen that in the most depressed position of the lower jaw both condyles are in the most forward and downward position near the eminentiæ articulares, from which position

Fig. 186

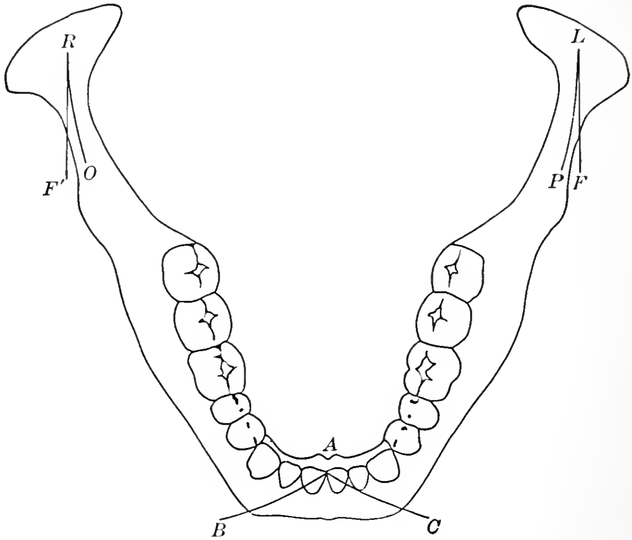


Diagram illustrating forward and lateral excursions of the mandible. R. O, path pursued by right condyle when jaw is rotated to the left about L; L P, path pursued by left condyle when jaw is rotated to the right about R; R F' and L F, paths pursued by right and left condyles respectively when mandible is carried bodily forward.

it is impossible to produce any lateral movement. Lateral movement and depression in any combination of these two are always, therefore, inversely related to each other.

Lateral movement may also be combined with forward translation of the jaw, its rotation about a vertical axis then occurring at the place in which the condyle through which it passes is fixed in the glenoid fossa. This means simply that the condyle, about which rotation in the lateral movement has occurred, is not in its distal position in the fossa, but has been carried forward along with its fellow of the opposite side. It becomes evident that these movements are similarly inversely related, for the farther forward one condyle is carried, the less distance remains to the other for rotation about it. It may be said that the condyle in the most distal position—the one about which rotation takes place—

always occupies a point in the path pursued in their dual forward movement. The return movements partake of the character of their constituents as may be seen above.

The various combinations of depression with forward translation, and the addition to these of changes in the direction of the horizontal axis of rotation passing through the condyles, which their independent movement forward produces, gives to the mandible a range of movement beyond that of any other joint in the body. Within the limitation imposed by the joint ligaments, and when the teeth are not in contact, the position of the jaw at any one time is determined by the balance established between the opposed pairs of muscles which produce its movements. When the teeth touch, however, they beome a factor in determining the position of the forward end of the mandible. It is evident, therefore, that so long as they are in contact, their form and position has much to do with the position of the jaw and its paths of movement. The slight laxity of the ligaments, and the compressibility of the tissues intervening between the bones and the varying pull of the muscles allow some slight latitude in the paths pursued.

The Teeth.—The jaws are equipped with the teeth in two opposed series which serve as specialized organs in the mechanical subdivision of the food. As the armament for the fixed and moveable elements of masticating apparatus they are brought into functional relation by the muscles operating the mandible. In the typical or ideal denture they are of such form and arrangement as to best subserve the interests of the masticatory function.

In order to comprehend the various relations which the teeth have during the functional activity of the mechanism, and to see how its ends are best subserved by their form and arrangement, it will first be necessary to study the teeth of each jaw separately, particularly with regard to their occlusal surfaces. Then, as the position of occlusion is the ultimate one toward which the mandible tends in all its masticatory efforts, it will be necessary to study the relative position of these morsal surfaces when the teeth are in occlusion, and then their relation during the masticatory movements of the mandible may be understood. Inasmuch as we are considering them as mechanical appliances solely, no attempt will be made to give their anatomy except as it concerns this matter.

As viewed from their occlusal surfaces, the teeth (Figs. 187 and 188), are seen to be arranged in the jaws in two arch-shaped series of sixteen teeth each. The outline of the arch in general is that of a parabola. While it varies considerably within the limits of the normal, as will be seen under the head of Temperament, its form is related to several other variable factors to be considered conjointly later in this chapter, and variations in this particular may occur which are not at the expense of the mechanical effectiveness of the apparatus. The arch outline is largely determined by the position of the individual teeth, but is affected by their size—both actual and relative—and their shape. The general proportion existing between the size and form of the individual teeth in either

the upper or the lower series is fairly constant. Slight variations occur, but as they are more important from a cosmetic than from a functional standpoint, they will not be considered here. The proportion between the corresponding teeth of the upper and lower series of any denture is also practically constant, the individual teeth in one jaw being nearly always associated with those of corresponding size and shape in the other. This will be seen more clearly when their occlusion is discussed.

Fig. 187

Occlusal surfaces of the upper teeth.

Fig. 188

Occlusal surfaces of the lower teeth.

The outlines of the upper and lower arches correspond in shape in order that the teeth may be opposed throughout their series, except that the upper is slightly larger and overhangs the lower externally. This difference in size is necessary in order that the fixed base shall present a sufficiently large surface for contact during the excursions of the moveable arm and it is extended in the direction of these movements. This is due to the greater size of the upper teeth and the greater segmental form of the arch: both the overhanging and difference in size decrease from the median line backward.

The teeth of each arch (Figs. 187 and 188) are seen to present an unbroken series of occlusal surfaces extending from the terminal molar on one side to that on the other. Besides giving greater surface area for masticatory purposes, this approximal contact provides a mutual support for the teeth which is of great value. When the character of man's food is remembered, it will be seen that this provision is also of some importance for the protection against injury of the soft tissues of the interproximal space.

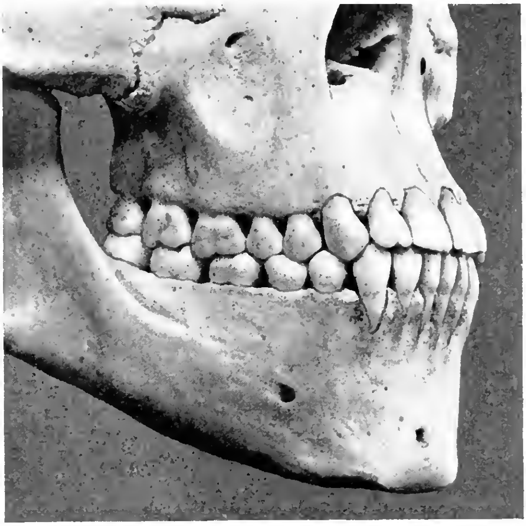
The teeth are divided into four classes anatomically, and their functions as mechanical instruments more or less correspond to this division. As viewed from their occlusal surfaces, (Figs. 187 and 188), it will be noted they are well-shaped for their several offices. The incisors are designed to cut off definitely sized masses of food, and their morsal surface is in the form of a broad blade, the labial and lingual surfaces meeting at an angle at the incisal edge. The canines in the lower animals serve largely for prehension—to pierce and hold the more resistent food, and among the carnivora to guide the lower jaw into place. In man these functions are largely rudimentary, the tooth being intermediate in function between the incisors and bicuspids. It has a double blade ending in a well defined point. The bicuspids, as their name implies, have two cusps, and are intermediate between the canines and molars. While their function is largely to crush and press the food, they participate in trituration, which is the characteristic office of the molars. The greater sharpness of their cusps fits them more for piercing than for grinding. The molars are the grinding teeth proper, for which their tuberculated surfaces are well designed. The cusps alternate with fossæ and grooves, and are joined by ridges which afford a surface most effective for trituration as will be seen later.

It will be observed of the molar and bicuspid series of cusps and depressions of each jaw, that as they are higher and larger anteriorly, they are smaller and shorter as the distal end is approached, so also there is a diminution in the distance between them both mesio-distally and bucco-lingually.

The Occlusion of the Teeth.—When the ideal or typical denture is viewed in occlusion, (Fig. 189), it will be seen that there is a definite mutual relation of the occlusal surfaces of the teeth. It will be observed that there are two different types of occlusion—first, that corresponding to the incisors and canines, in which the morsal edges do not meet end to end, but those of the lower teeth rest upon the lingual surfaces of the upper; and second, that corresponding to the molar and bicuspid teeth, where considered collectively their cusps are either received into fossæ or depressions in the occlusal surface of the opposing series, or overlap the buccal or lingual surface of their opponents. It is notable that with the exception of the lower central incisors and the upper third molars, each tooth is opposed by portions of two others. This provision serves to dissipate the force of impact in occlusion, and tends to preserve the integrity of the denture; for with this

arrangement the loss of a tooth in one arch does not mean the loss of a tooth in the other through lack of antagonism.

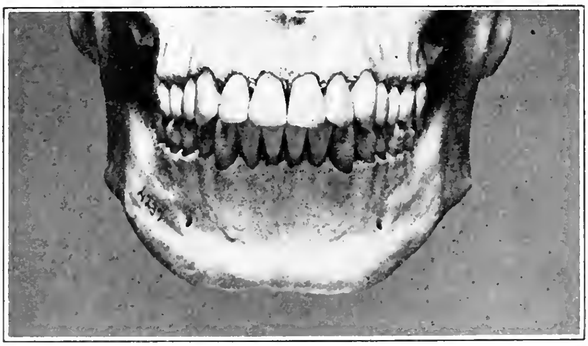
FIG. 189



Upper and lower teeth in occlusion. (From photograph of specimen in the Wistar Institute of Anatomy.)

The Occlusion of the Incisors—The typical occlusion for the incisors is shown in Fig. 190, in which it will be seen that the upper incisors overhang the lower for about one third their labial surfaces. This

FIG. 190



Occlusion of the incisor teeth. (From photograph of specimen No. 4237, Wistar Institute of Anatomy.)

relation is spoken of as the normal overbite of the incisor teeth and obtains in a large percentage of cases. The angle formed by the long axes of the upper and lower incisors differs much in individuals, as will be seen under Temperament, and the contact between the two varies

in consequence. In some the angle is so obtuse that there is considerable contact between the labial surface of the lower and the lingual surface of the upper incisors. The size of the arch of the upper may be so great that the lower teeth are not in contact with the upper in the position of occlusion, only coming in contact when the lower jaw is protruded in incision. The so called "edge-to-edge" bite of the incisors, which is seen in those temperaments in which the overbite has been short and the teeth have worn, or have been originally erupted in this position (Fig. 191, B), is within the range of the normal but is a less effective mechanical arrangement for incision.

FIG. 191

A B C

Occlusion of the incisor teeth. A. Normal overbite; B. Edge-to-edge bite; C. Upper incisors distal to lower. (Grevers.)

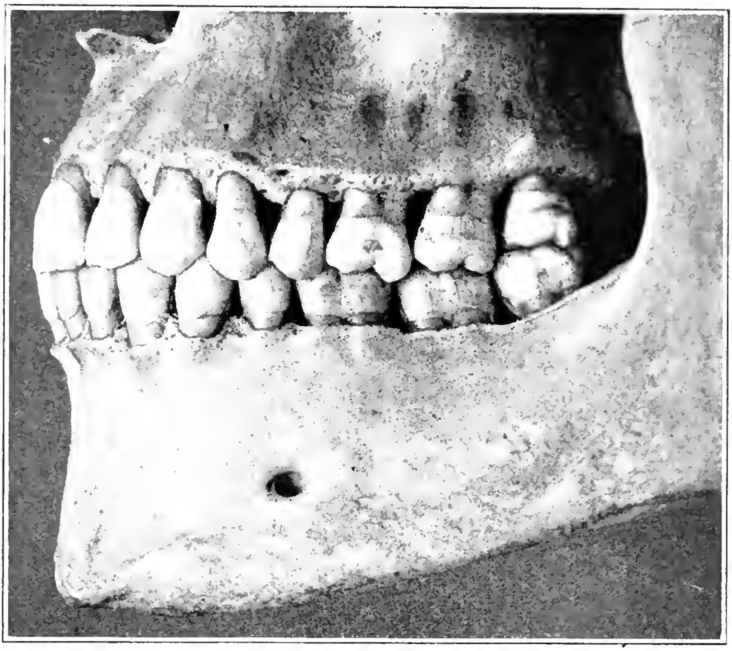
The condition presented by Fig. 191, C, in which the upper in-incisors occlude lingually to the lower is less effective still, because the lower jaw cannot move backward to bring the teeth into contact.

In a typical denture Balkwill[1] has pointed out with regard to the scissors-like action of the front teeth, that as they are wedge shaped, he "expected to find the angle of the wedge equally divided by the circle of motion, which would give the greatest dividing power," but this is not the case. The angle of the wedge points more outward in the upper and inward in the lower, and he reminds us that in closing the teeth, there is a backward as well as an upward motion. Burchard has pointed out the effect of this motion upon the direction of the impact of the teeth during closure of the jaw; that unless there were a backward movement at the same time the effect would be to drive the upper incisors forward. Constant[2] has shown that the direction of impact in ordinary closing is almost vertical.

The Occlusion of the Bicuspids and Molars.—The bicuspids and molars on each side viewed collectively (Fig. 194), may be considered as consisting of a series of cones or cusps alternating with fossæ or depressions, and so fitted together when the teeth are in occlusion that the fossæ receive cusps of the opposing teeth. The inner line of cusps of the upper are received into the fossæ between the outer and inner cusps

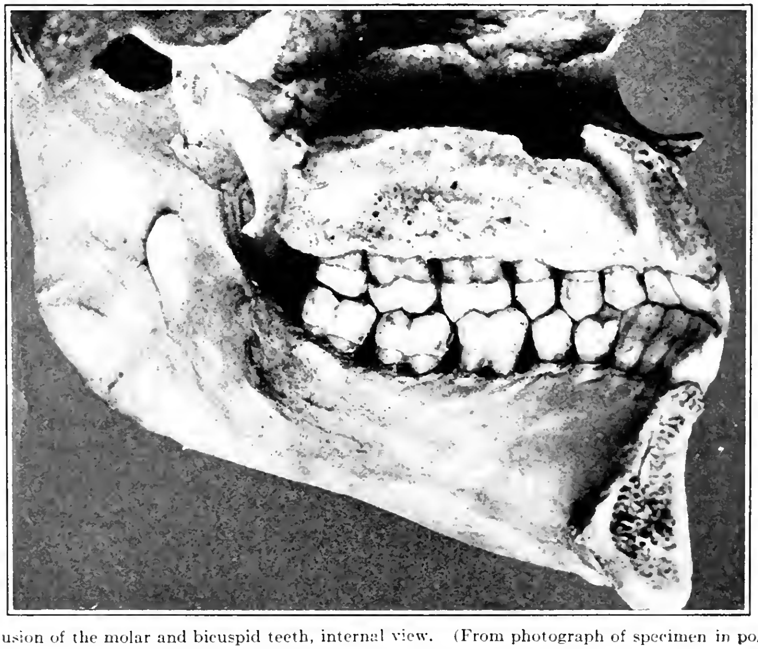
[1] Transactions Odontological Society of Great Britain, Vol. v., p. 133.
[2] Naked Eye Anatomy of the Human Teeth, p. 187.

Fig. 192



Occlusion of the molar and bicuspid teeth, external view. (From photograph of specimen in possession of Dr. F. A. Peeso.)

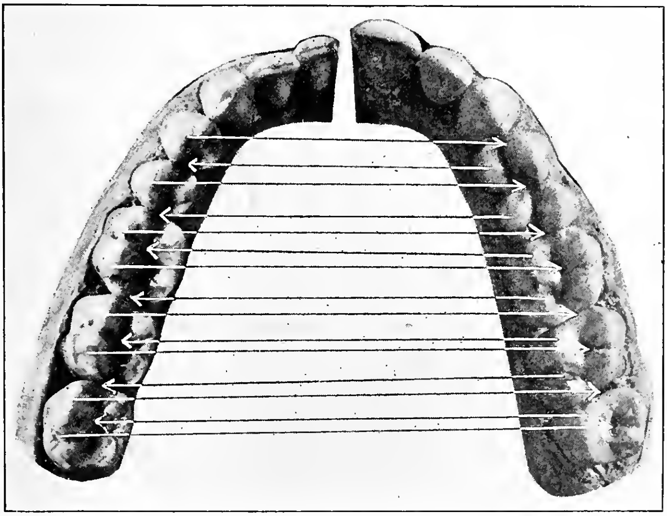
Fig. 193



Occlusion of the molar and bicuspid teeth, internal view. (From photograph of specimen in possession of Dr. F. A. Peeso. Same specimen as Fig. 192.)

of the lower (Fig. 193), the outer line of cusps of the lower being correspondingly received into fossæ in the upper (Fig. 192). Thus the lingual cusp of the first upper bicuspid (Fig. 193) is received, between the buccal and lingual cusps of the lower bicuspids, the point of the cusp corresponding to the line between the mesial marginal ridge of the second and distal marginal ridge of the first. Similarly, the lingual cusp of the second upper bicuspid is received at the line of contact between the marginal ridges of the second lower bicuspid and first molar. The mesio-lingual cusp of the first upper molar fits into the central fossa of the first lower molar, while the disto-lingual cusp occupies a position in relation

Fig. 194



Occlusion of the molar and bicuspid teeth, occlusal view. Lines are drawn from the lingual cusps of the upper teeth and buccal cusps of the lower to the corresponding depressions into which they fit. (From photograph of specimen in possession of Dr. F. A. Pecso. Same as Figs. 192 and 193.)

with the adjoining marginal ridges of the first and second lower molar teeth, *i. e.*, in the depression between the disto-lingual and buccal of the first lower molar and mesio-lingual and mesio-buccal of the second lower molar. The second upper molar occludes similarly with the lower second and third molars, while the third upper molar varies in this respect as it varies in form. The large lingual cusp, usually found on this tooth, however, normally occupies the central fossa in the third lower molar.

The buccal cusps of the lower are received into the fossæ and depressions of the upper teeth as follows (Fig. 192): The buccal cusp of the first lower bicuspid is in relation with the distal marginal ridge of the canine and the mesial marginal ridge of the first bicuspid (Fig. 194). This is less like a cup-shaped depression than any which succeed in this description. The second bicuspid has its buccal cusp received in the depression between the buccal and lingual cusps of both upper bicuspids,

its point being in definite relation with their adjacent marginal ridges. The mesio-buccal cusp of the first lower molar rests in relation with the adjoining marginal ridges of the first upper molar and the second bicuspid, while the large buccal cusp is received in the central fossa of the first upper molar. The disto-buccal cusp of the first lower molar, which is present in 50 per cent. of cases, is usually so distally located that it shares with the mesio-buccal cusp of the second lower molar the space between the cusps of the first and second upper molars and is in contact with their adjacent marginal ridges; or it is forced to the lingual to be lost in the distal marginal ridge. The mesio-buccal cusp of the second lower molar has just been located, while the remainder of the tooth is similarly related to the upper first and second molars as the first molar is to its two antagonists. The third lower molar varies so in form that it is difficult to say what is its typical occlusion. The two types most commonly seen (Broomell)[1] are those with four or five cusps respectively, the occlusion being similar to the molars already described with regard to the mesio-buccal and buccal cusps in either case, while where the fifth cusp is present, it occludes simply with the distal portion of the upper molar.

The buccal cusps of the upper molars and bicuspids are sharper than the corresponding lingual cusps (Fig. 195). They are related to

FIG. 195

Section through upper and lower teeth in occlusion, showing relative height and sharpness of buccal and lingual cusps. (Cryer.)

the lower teeth as follows: (Fig. 192.) That of the first bicuspid is received in the groove between the buccal cusps of the lower bicuspids and to the buccal side of the teeth. That of the second corresponds to the space between the buccal cusp of the second lower bicuspid and mesio-buccal of the first lower molar. The mesio-buccal of the first upper molar is received in the buccal groove of the first lower molar, the disto-buccal cusp occupying the disto-buccal groove, where the lower molar

[1] Broomell: Anatomy and Histology of the Mouth and Teeth.

has five cusps, or the space between the second molar and the first, where it has four. The buccal cusps of the second upper molar occlude so similarly to those of the first that they require no mention, while the two buccal cusps of the third likewise similarly occlude, except where the lower molar has no disto-buccal cusp when only its last cusp is in relation with the distal surface of the lower tooth.

As to the lingual cusps of the lower teeth (Fig. 193), they are in general smaller and more pointed (Fig. 195), than the buccal. A marked exception exists in the case of the first lower bicuspid whose lingual cusp is frequently so rudimentary as to be represented only by a ridge of enamel; the second is sometimes similarly formed. Bonwill[1] has pointed out the lack of function of this cusp of the first bicuspid, which fact will be seen more clearly when the functions of the teeth are described. When present this cusp is in relation only with the mesial slant of the lingual cusp of the first upper bicuspid. The lingual cusp of the second is lingually placed to the space between the lingual cusps of the two upper bicuspids, while the mesio-lingual cusp of the first lower molar is similarly placed between the first molar and second bicuspid. The disto-lingual cusp corresponds in position with the lingual groove of the first upper molar. The lingual cusps of the second molar are similarly related to the first and second upper molars, and this is likewise frequently true for the third lower molar, with the exception of its disto-lingual cusp, which, having no groove with which to be in relation, touches only the distal incline of the single lingual cusp of the upper wisdom tooth.

It will be noted that the cusps received into fossæ are the more rounded, that the cusps which overlap are the sharper and the smaller. (Fig. 195.)

In the upper jaw it is noted that the fossæ are separated antero-posteriorly or mesio-distally by the transverse ridges of the bicuspids and by the mesial marginal and oblique ridges of the molars. These ridges are received by the grooves separating the buccal cusps of the lower teeth. The lower fossæ and depressions which receive the lingual cusps of the upper series are similarly separated, and these ridges are received into the grooves separating the lingual cusps of the upper teeth (Fig. 194.) It is evident that in order to move the jaw in any direction it must be depressed to disengage the cusps from these fossæ.

The actual height of the cusps and the corresponding depth of the fossæ vary greatly in different individuals and will be discussd later under the head of Temperament. It may be mentioned here however that this variable factor is one of that related group which will be considered later in this chapter. Bonwill[2] has stated that there is an almost constant relation between the overbite of the incisors and the length of the cusps of the bicuspid and molar teeth. (Fig. 196.) Where the overbite is considerable, the molars and bicuspids will usually be found to possess high cusps, the overhanging of the buccal cusps of the upper being an index of their length, while short cusps are associated

[1] American System of Dentistry, Vol. ii., p. 495. [2] Ibid., p. 488.

with a small amount of overbite. In either event the cusps grow proportionally shorter from before backward. While this proportion

Fig. 196

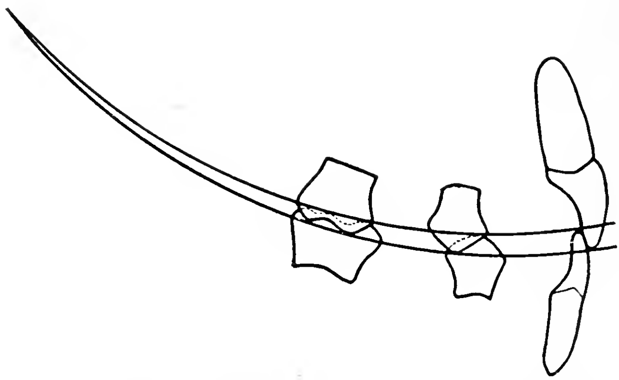
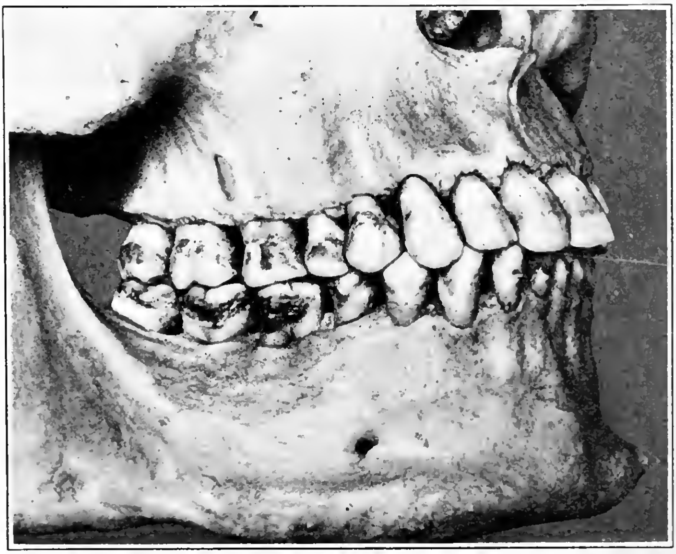


Diagram showing typical proportion between cusp length and overbite. Modified from Bonwill.

is fairly constant for typical dentures, many instances of a departure from it are found. A denture conforming closely to the description of the typical denture in every particular except this, is shown in Fig. 197.

The canine tooth occupies a position between the incisors and the

Fig. 197



Denture typical in other respects exhibiting disproportion between cusp length and overbite It will be noted that the cusps of the first molar are much worn as this is oldest tooth in mouth (From photograph of specimen from Dr. Cryer's collection.)

masticating teeth and hence is intermediate in the character of its occlusion. Where from the shape of the arch it continues the line of the

molars and bicuspids, it partakes more of their type of occlusion, and its overbite corresponds to the overlapping of the molar and bicuspid cusps and is proportioned to them in this regard. When its position is more in the line of the incisors, it partakes of their type of occlusion, its overbite corresponding with theirs, while if it is intermediate in position, it participates in the character of both types of occlusion.

This relation of cusp length and overbite is another of the related variations to be discussed presently. When the overbite and cusp length are not thus proportioned the condition may be referred to as abnormal.

We next come to discuss some peculiarities of the occlusion of the bicuspid and molar teeth, which are so closely related to the manner of movement of the mandible and have so important a bearing upon the efficiency of these teeth as masticatory organs, that it will be necessary to bear in mind the movements of which the lower jaw is capable in order to understand the functional significance of these characteristics. If a curved line be drawn touching the summits of the buccal cusps of the upper teeth from canine to third molar, it will more or less accurately correspond to the arc of a circle with its convexity downward. (Fig.

Fig. 198

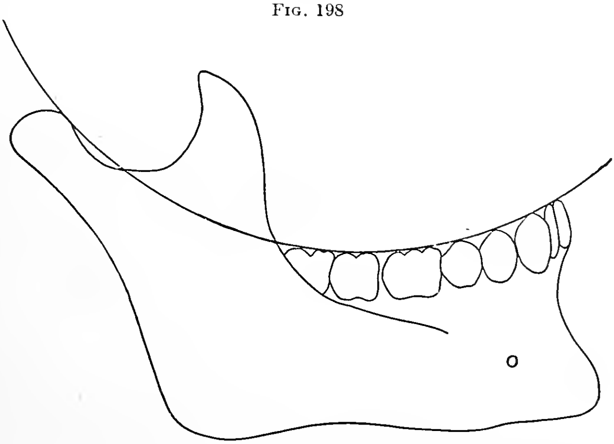
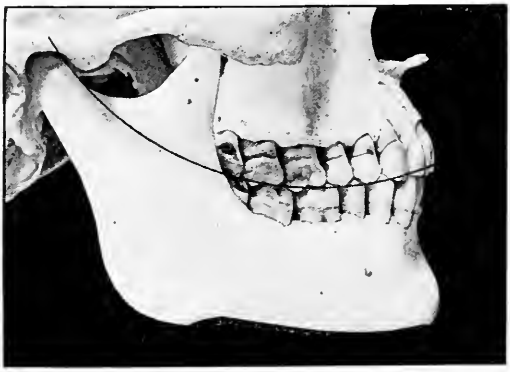


Diagram illustrating the "compensating curve," or the "Curve of Spee."

198.) The upper lingual cusps will be found to occupy a similar line and both series of cusps of the lower teeth correspond also to the arc of a circle. This condition is to be attributed to differences in the level of the teeth and in the direction of their long axes as they are placed in the alveolar process. The long axes of the upper teeth anterior to the second bicuspid are inclined toward the median line of the denture, that of the second bicuspid being practically vertical, while the teeth distal to it are placed at a higher level in the bone and have their long axes increasingly inclined away from the median line. In the lower jaw a corresponding condition is found, successive cusps of the series being placed at higher levels in each direction from the mesial cusps

of the first molar which marks the lowest portion of the curve. (Fig. 198.) This is frequently spoken of as the "compensating curve" of the molars and bicuspids, and also as the "Curve of Spee," by whom it is described.[1] This curve varies considerably in different individuals. In its most ideal form, if continued in a projection of the jaw upon the vertical sagittal plane, it touches the anterior face of the articular surface of the condyle. (Fig. 199.) It more frequently passes posterior to this than anterior. In typical dentures its form has a definite relation to two of their characteristics which have already been mentioned, viz., the length of the cusps of the teeth, and the path which the condyles pursue in the forward excursion of the jaw. The relation existing between the curve and these two factors may be stated thus: the longer the cusps of the molars and bicuspids the shorter will be the radius of this curve, and the shorter the cusps the longer will be its radius; also, the greater

Fig. 199



The "Curve of Spee." Line passing through anterior face of condyle. (From a photograph of a specimen in the Wistar Institute of Anatomy.)

the inclination of the glenoid fossæ and hence the greater the angle between the path of the condyles and the horizontal, the less will be the radius of this curve, while the more nearly horizontal is the path of the condyles in their forward movement, the longer will be the radius of the compensating curve. To understand the bearing of this feature of the occlusal surfaces of the bicuspid and molar teeth upon the forward excursion of the jaw, let us see what takes place if this movement occurs and the lower teeth maintain contact with the upper, simply sliding forward over their occlusal surfaces. It must be evident that the path of the jaw would be determined during this movement by the condyles and fossæ posteriorly and by the teeth anteriorly. The object which this arrangement serves is that all of the bicuspid and molar teeth shall be in contact within a certain range of the forward and backward movement of the mandible. It likewise provides that when the mandible is elevated into contact with the upper jaw not too far for-

[1] "Die Verschiebungsbahn des Unterkiefers am Schädel." F. Graf v. Spee; Arch. f. Anat u. Physiol, 1890.

ward of the position of occlusion, the lower teeth may simultaneously strike their opponents and be able to preserve a sliding contact with them in the retraction of the jaw to the position of occlusion.

We have already seen that the position of the lower jaw at any time when the teeth are in contact is determined anteriorly by this contact of the teeth, and posteriorly by the glenoid fossa upon which the condyle rests. Its path, therefore, during a sliding contact of the teeth, would be determined anteriorly by the teeth and posteriorly by the fossæ over which the condyles move. That there must be a correspondence between these is evident. In order to understand how it is possible for this sliding contact of the teeth to take place, and for sake of simplicity in description, let us suppose that the opposed surfaces are smooth instead of being broken up into cusps and fossæ. (Fig. 199.)

In order that the lower teeth may slide upon the upper and the contact be interrupted at no point, the sliding surfaces must be either perfectly flat or represent a curved plane, a section of which would be the arc of a circle. These are the only two kinds of surfaces between which a sliding contact could take place. In the former case the sliding body moves in a straight line, in the latter in the arc of a circle. That the condyle must move in a path harmonious with that pursued by the teeth of the lower jaw becomes evident when it is remembered that the jaw moves as a whole. Where the sliding surfaces are planes and the jaw moves in a straight line, the condyle moves in a line parallel to this or identical with it. When they correspond to the arc of a circle, the condyle moves also in the arc of a circle, its path concentric with or identical with it. If this did not occur the sliding contact between the teeth would be interrupted.

We find therefore that when the general line of the teeth is that of the arc of a circle, that portion of the fossa over which the condyle slides is likewise an arc which is either identical or concentric. And the more nearly the plane of the teeth approaches a straight line or an arc with an infinite radius, the more nearly straight is the floor of the fossa. These two associated and related characteristics vary therefore in individuals. With a well defined curve of the molars and bicuspids there must be a corresponding slant of the glenoid fossæ to permit the condyles to descend as the jaw sweeps round this curve, while where they are more nearly in a straight line and the jaw may move the more bodily forward, the fossæ do not incline downward so much but permit the condyles to go more horizontally forward.

The addition of cusps to the surface of the teeth complicates very much this sliding contact. In fact the surfaces do not slide as such, but the points of the cusps of the lower teeth glide upon the fossæ of the upper. We have already seen that from before backward the cusps get proportionately shorter and, of course, the fossæ into which they are received are proportionately shallower. As the mandible is moved forward these cusps have the effect of separating the jaws, or of rotating the mandible about a horizontal axis passing through the condyles. This is produced by the lower buccal cusps sliding upon the anterior walls of

their fossæ, while the fossæ in the lower teeth containing the lingual cusps of the upper teeth slide upon them. This provision keeps the cusps in contact during the forward movement, until the incisors come into action, and where the normal overbite exists, the lower centrals then slide down the lingual surface of the upper incisors and separate the distal teeth. Usually when the incisors are edge-to-edge, all the teeth distal to them are out of contact.

From what has been said it will be seen that the buccal cusps of the lower teeth and the lingual cusps of the upper are the ones which it is most important should conform to the compensating curve, since they are in contact with the fossæ. One of the commonest variations from this typical arrangement which will be observed, is that in which the distal cusps of the upper molars are below the curve mentioned, the long axes

Fig. 200

The "Curve of Spee." Short cusps and long curve. Line passing through anterior face of condyle. (Specimen No. 4237, Wistar Institute of Anatomy.)

Fig. 201

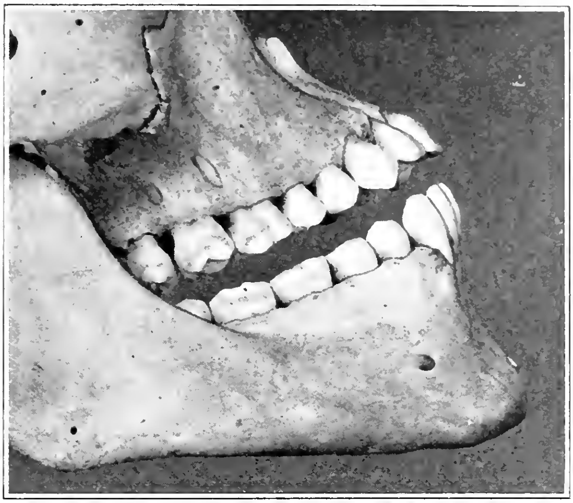
The "Curve of Spee." Short cusps and long curve. Line passing distal to anterior face of condyle. (From photograph of specimen No. 800, Wistar Institute of Anatomy.)

of the teeth being almost vertical (Fig. 189). In such cases if the jaws are typical in other respects the mesio-buccal cusps will be found more or less worn down to conform to the general plan, the disto-buccal remaining unworn, because they occupy space between the lower teeth and not in their buccal grooves.

Another characteristic of the molar and bicuspid teeth may be observed in Figs. 202 and 203, in which it may be seen that their buccal and lingual cusps are not on the same level, the buccal cusps occupying a higher relative position as we proceed backward from the first bicuspid. In the upper jaw the lingual cusp of the first bicuspid is usually higher than the buccal, the cusps of the second bicuspid being either on the same level or the buccal being a little higher (Fig. 202). The buccal cusps of the first molar are successively higher than the lingual, and this continues until we find those of the third molar relatively highest of all (Fig. 202). This condition obtains also in the lower jaw (Fig. 203). It is partly due to an actual anatomical difference in the height of the cusps as the tooth is viewed out of the mouth, and partly due to the increasing inclination of the long axes of the teeth in the

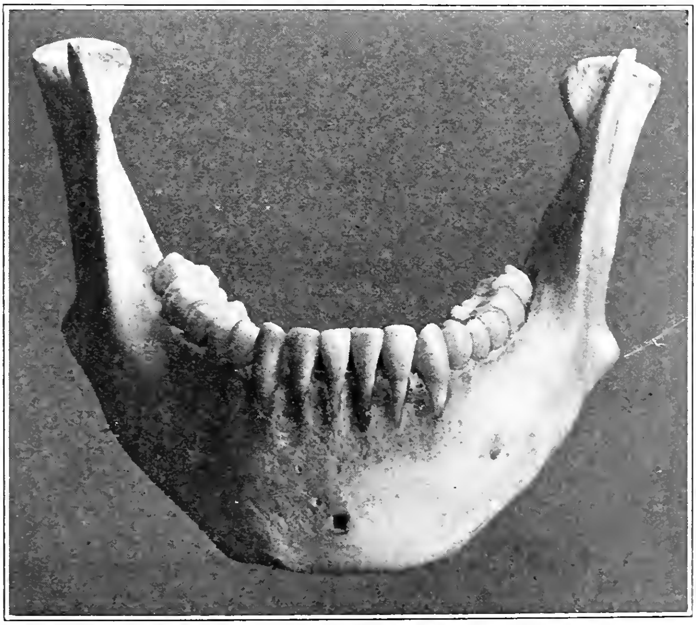
alveolar process. This is another of the related factors subsequently

Fig. 202



Upper and lower bicuspid and molar teeth, side view, showing relative height of buccal and lingual cusps of upper teeth. (From photograph of a specimen in the Wistar Institute of Anatomy.)

Fig. 203

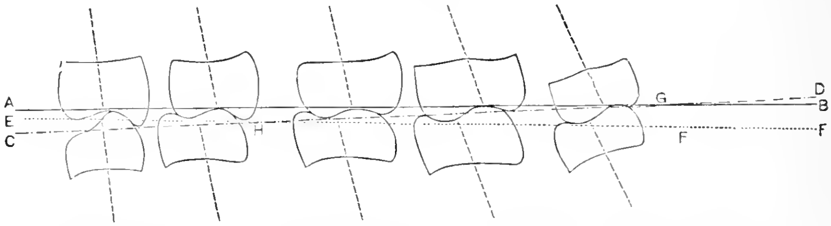


Lower bicuspid and molar teeth, front view, showing relative height of buccal and lingual cusps. Same mandible as Fig. 202. (From photograph of a specimen in the Wistar Institute of Anatomy.)

to be considered and varies with the path of the condyle. That this condition provides for the contact of the cusps in the lateral excursion

of the jaw has been well brought out by Walker[1] (Fig. 205). When the jaw is moved to one side with the teeth sliding in contact it rotates about a vertical axis passing through the condyle on that side, the opposite condyle moving inward, forward, and downward. On the side toward which the movement is taking place, the rounded buccal and the lingual cusps of the lower teeth slide upon and come in contact with the buccal and lingual cusps, respectively, of the upper teeth.

FIG. 204



Diagrammatic view of the relative height of the buccal and lingual cusps of the molar and bicuspid teeth. (Walker.)

On the opposite side the high buccal of the lower teeth slide up and come in contact with the high lingual of the upper teeth, which is rendered possible by the fact that the jaw is depressed on that side. If the condyle simply moved forward instead of downward as well, the buccal and lingual cusps might be of the same height and this same relation of the cusps would obtain, but as it moves downward the outer cusps have to be higher in order that there shall be compensation for

FIG. 205

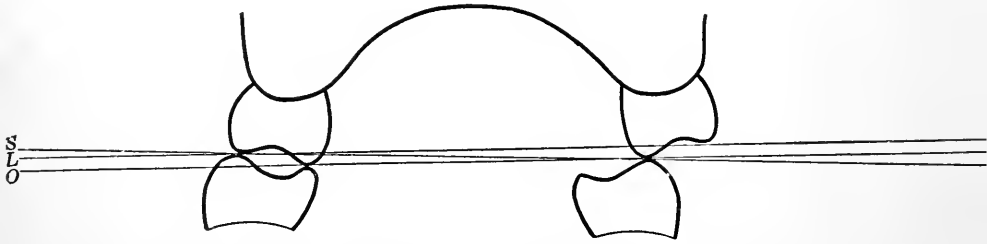


Diagram illustrating contact of cusps in lateral excursion of the mandible. Section through jaws at position of second molar. O P, line touching lingual cusps of upper molars; L R, line touching buccal cusps of upper molars; S T line touching buccal cusps of lower molars, showing the downward movement of the mandible on the right side necessary for contact of the cusps.

the rotation of the jaw about a horizontal axis passing through the stationary condyle.

This provision serves to balance the masticating force and prevent overstrain when the jaws are in occlusion in the lateral position. It provides contact of the teeth on both sides to resist the strain exerted by the pairs of levators which have simultaneously contracted. With

[1] The Dental Cosmos. Vol. xxxix., p. 789.

artificial dentures this condition may be imitated to advantage for a purpose to be discussed in a later chapter. Thus it will be seen that in the movement of the jaw forward or from side to side there are a series of cones which may be applied to the food, the series of cones or depressions so alternating and being so arranged in each jaw that within a certain range of movement the whole series of cones may be in contact with opposing surfaces of some sort. The immense functional value of this is obvious, and it is also apparent that this provision tends toward preventing overstrain and undue shock upon the denture.

In exerting the force by which the food is crushed, the jaw moves to what has been called the position of occlusion, from the various positions which it has assumed in biting through the food placed between the teeth. There are several ways in which the food may be crushed in such movements. It may be done by the action of a cone-shaped point not closely fitting its opposing surface, which is applied to the food and acts as a dividing wedge; or the cone may be received into a depression which it closely fits, the food being simply crushed as between two plane surfaces, or the cone may not fit the depression, there being space or spaces for the crushed food to escape, the cone in the depression acting somewhat as a pestle in a mortar. Two closely fitting plane or curved surfaces, when the force between them is exerted at a right angle to the surfaces, do not act well for crushing except for rather brittle substances. But if in addition to their approximation they slide upon each other, the crushing effect is increased.

A cusp received into an accurately fitting depression does not possess the greatest efficiency for crushing. Clearance spaces must be provided. During the operation of the denture as the food is pressed toward the buccal and lingual surfaces of the teeth, grooves between the cusps and the interdental spaces are provided for clearance. Grooves run down to the bottom of the depressions in the bicuspid and molar teeth, and the chief clearance channels are located between the buccal cusps of the upper and the lingual cusps of the lower. This carries the food lingually above the tongue so that it may be manipulated more easily, while bucally is carried downward into the sulcus between cheek and teeth, where, because of the peculiar musculature of the cheek and because the lower jaw is depressed below this point when the mouth is opened, the food is again carried in between the teeth. This overhanging of cusps also serves to protect the cheek on the outside and the tongue on the inside from being caught between the surfaces of the teeth.

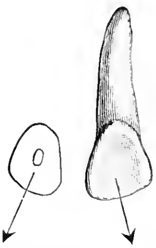
In addition to the fact that the forms of the occlusal surfaces of the teeth peculiarly fit them to act as the crushing organs of the mechanism we find that they are adapted for this function in other particulars. They are provided with the means of resisting the wear and stress which the constant activity of the apparatus entails.

The enamel of the teeth, the hardest tissue of the body, forms their external covering. It gives them a hard, resistant, and highly polished surface, and offers its greatest thickness to those parts most exposed to

wear. The enamel masses are also arranged to give the best mechanical support in resistance of the force exerted upon the teeth. The bulk of the tooth is composed of dentine which confers the necessary strength.

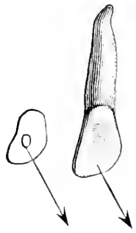
Resistance to the stress of mastication is provided for by the form and location of the roots of the teeth. These are all modified cones fitting into conical sockets, and as their long axes are generally in line with the direction in which stress is exerted upon them, the mechanical advantage is evident. The force upon the incisors does not always act to force them into their sockets (Figs. 206, 207, and 209). For the upper it serves to drive them forward as well as upward, and is resisted by the

Fig. 206



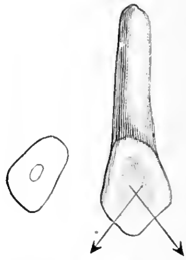
Line of resistance to force offered by upper central incisor. (Burchard.)

Fig. 207



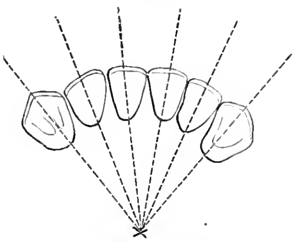
Line of resistance to force offered by upper lateral incisor. (Burchard.)

Fig. 208



Lines of resistance to force offered by upper canine, (Burchard.)

Fig. 209



Lines of resistance to force upon the lower incisors and canine teeth. (Burchard.)

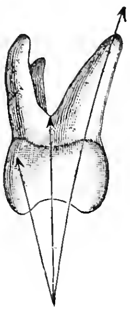
flattened labial surface of their roots. The canine is forced upward and outward and the labial surface of its root also serves to prevent displacement in this direction (Fig. 208). The six lower anterior teeth are forced downward and inward, the inclination of their roots and their arch-like arrangement resisting the strain upon them. The principal strain upon molars and bicuspids is vertical, their roots being well disposed to resist it (Figs. 210 and 211). The lateral stress upon these teeth, which is largely determined by the height of their cusps, is resisted by the direction of their roots. As the principal lateral strain upon the upper molar and bicuspid teeth is inward, we have their long axes inclined in the direction to resist this (Fig. 210).

The opposite is true of the lower molars whose long axes resist a

force tending to displace them downward and outward—the direction in which strain in mastication is applied to them. (Fig. 211.)

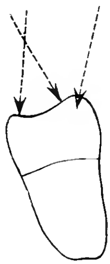
The character of the retentive tissues of the teeth tends to prevent and resist strain upon them. The pericementum is composed largely of connective tissue fibres extending from the tooth to its socket, and so disposed as to support the tooth even under great pressure on its long axis, but by their elasticity permitting slight movement in any direction. The membrane is also highly vascular, particularly in youth, which doubtless also contributes to its resiliency. This mobility enables the tooth to resist far greater force exerted upon it than if it were solidly attached to the bone, and the independent mobility of the teeth makes the denture capable of resisting greater strain than if they were a united mass. The teeth mutually support each other because of their approximal contact, so that each tooth is thus able to resist greater force. The

Fig. 210



Lines of force upon an upper molar. (Burchard.)

Fig. 211



Lines of force upon a lower molar. (Burchard.)

pericementum has upon the tooth, a vital protective influence as well as a cushioning effect. Black[1] has reminded us that its tactile sensibility is a constant safeguard against overstrain.

It has been stated that there are a number of characteristics of the typical denture which are variable, and that they are all more or less directly related, and that they vary harmioniously and proportionately.

Those which have been mentioned are:

1. The size and shape of the individual teeth.
2. The overbite of the incisors and the cusp length of the molars and bicuspids.
3. The shape of the dental arch.
4. The curve of Spee or "the compensating curve."
5. The inclination of the long axes of the teeth.
6. The relation of the buccal and lingual cusps of the bicuspid and molar teeth.
7. The shape of the condyle and the inclination of the glenoid fossa.

In what may be called typical dentures variations in any of the above may and do occur without the creation of a departure from the mechanical

[1] The Dental Cosmos, Vol. xxxviii., p. 476.

design, provided they are associated with variations in other characteristics to which they are directly related. The mutual relation of these has been pointed out as they were described. The only item mentioned which is not a characteristic of the denture is the last, which of course determines the path and the manner of movement of the jaw. The relationship existing between this and the anatomical form of the teeth is the most important one to bear in mind. It has been well stated by Walker[1] that "there is a certain definite co-relation between the morphology of the morsal surfaces of the teeth" and the path pursued by the condyle.

The foregoing description has been that of the ideal or typical masticatory apparatus rather than the normal or usual. Few dentures absolutely perfect in every particular exist, it is indeed doubtful if any do. A number which are approximately perfect have been used to illustrate this chapter. Nature has been prolific in her provision for man's needs in this regard, and while she has furnished few with a perfect mechanism, yet within the bounds of what may be termed the normal, many dentures exist, which although they fall short of the mechanical design described in many particulars, nevertheless serve their possessors for purposes of mastication in an entirely satisfactory manner. The human organism frequently displays its ability to adapt itself to serious shortcomings in the work of this apparatus, but it must not be forgotten that the greater the departure from this typical design the less must be the efficiency of the mechanism.

THE PREPARATION OF FOOD.

Incision.—Having studied the characteristics of the masticating mechanism, we are prepared to discuss the method by which it functionates. Prehension, or the seizing of the food, is a function of the teeth of some of the lower animals but is unnecessary with civilized man. His first act is that of incision, although with the development of cutting instruments for food and the cultivation of a conventional use of them, even incision is confined to few articles. In the performance of this act the lower jaw is depressed from the position of occlusion and carried forward, the condyles moving approximately evenly in their fossæ in this direction, rotation of the jaw about them occurring sufficiently to permit a grasping of the substance to be incised. The food is carried through the lips in contact with the upper incisor teeth, when the jaw is elevated and partly retruded, the edges of the lower and upper incisor teeth being approximately opposite during the movement. The more resistent the food, the more nearly will the teeth be opposed in their course through it. As soon as their cutting edges come in contact, the retraction of the jaw is so combined with elevation that the edges of the lower incisors slide up the lingual surfaces of the upper, the incisal edges passing each other somewhat after the order of shears. In some cases where the normal overbite of the incisors described

[1] The Dental Cosmos. Vol., xxxviii., p. 576.

on page 214, does not exist, the curve of the occlusal surfaces of the molars is such that the third molar in its advanced position due to the protrusion of the jaw, is in contact with the second molar during incision, thus tending to relieve the strain upon the incisor teeth. This is usual where there is an edge-to-edge bite, but with a normal overbite it does not occur.

It will be noted (Fig. 190), from the curve of the occlusal edges of the upper incisors, the laterals usually being lower than the centrals, that their edges are first opposed in the centre, and thus the shearing action is carried on in both directions from this point. It is also noted that when the edges come into contact the food has been practically severed, and that until this time, the direction of the stress upon the upper teeth is almost that of the long axes of the teeth, while for the lower incisors this is not true until the cutting edges begin to slide upon the upper incisors, the stress up to this time being such as to displace them downward and forward.

Mastication.—Man's diet consists of food of various degrees of physical consistence, and while the tendency of civilization is toward such preparation of the food as to lessen the necessity of mastication, some of it, indeed, requiring none at all, yet the bulk of it demands a thorough trituration to best subserve the body's needs. The principal articles of human diet requiring mastication are meats (animal fibre), vegetable fibre, and cereals, and foods made from them. Some of the other vegetable products have a hard protective covering which must be broken through to give access to the digestive juices, for it has been demonstrated that some of them, as grain for instance, might pass unaltered through the alimentary canal if this were not done. From a mechanical standpoint the essential feature of mastication is to crush these various articles of food in order to break up their physical organization and reduce the size of their separate particles. The object of this operation is to facilitate the action of the digestive fluids upon the food and render its passage through the alimentary canal easily accomplished.

After the food has been incised or after an appropriately sized portion has been introduced into the cavity of the mouth, it is passed back by the tongue to the bicuspid and molar teeth to be reduced to small particles. In accomplishing this the jaw executes two more or less distinct kinds of movements and there are various combinations of them. The first of these is the direct up and down motion of the jaw in which it moves in the sagittal plane; the morsal surfaces are separated and the food placed between them is crushed when they are approximated. The great crushing ability of tuberculated surfaces is a well-known mechanical principle, the cones acting as wedges to divide the food. The efficiency of the denture in this movement is proportional to the height of the cusps, sufficient clearance spaces being necessary, as has heretofore been shown. This motion is peculiar to the carnivorous animals, their masticating efforts being practically limited to it. Black has stated that this kind of masticating motion is used

almost exclusively in the mastication of meats by persons with fairly normal dentures. The ultimate position attained by the jaw in this motion is, of course, as nearly that of occlusion as the crushed fibre interposed between the surfaces will allow. The jaw does not always close so that the cusps are exactly opposite their respective fossæ: hence a small sliding takes place to bring the teeth together, but in the main the movement is toward the position of occlusion, the food being squeezed in a pulpy mass buccally and lingually.

The other motion, which in its simplest form is similar to that characteristic of herbivorous animals, is produced during the lateral excursion of the jaw. The mandible is depressed and carried to one side, the condyle on the side toward which it is moving usually remaining in the distal portion of the fossa, that of the opposite side being pulled forward. The jaw is then elevated in this lateral position, the food being interposed, and the rounded buccal cusps of the lower teeth on this side come into relation with the sharp buccal cusps of the upper, the inner cusps likewise touching; the food is crushed and cut, a portion of it being left to occupy the fossæ between the inner and outer cusps. The jaw is then pulled upward and inward toward its occlusal position, the food being crushed between the rounded and strong lower buccal cusps and upper lingual cusps. With this movement is frequently combined a slight protrusion, though this is largely a matter of habit, and is not by any means necessary for the most efficient action of the teeth. While this is occurring on one side, on the other the teeth are not brought into the same functional relations. The high cusps above and below are usually in contact at one or more points, which serves to prevent strain and offers resistance to the elevator muscles of this side which contract simultaneously with those on the opposite side. This side does not functionate during the excursion of the jaw to the other side, because only the upper lingual and lower buccal cusps are in contact. This motion is used in the crushing of cereals and food made from them, and is by far the more effective of the two. It is also used in crushing most of the brittle and very hard substances. In the normal denture mastication of this nature takes place instinctively upon the two sides alternately, although this is largely a question of habit.

The force required in crushing various articles of human diet, by an up and down motion, has been investigated by Black[1]. He used an instrument, consisting of two molar teeth carved from brass, which are forced against corresponding teeth by the direct thrust of a sliding bar. Head[2] has reduced the figures thus obtained by Black by the use of a device for producing a triturating as well as a crushing movement. He utilized "a natural skull with practically perfect molars of average size." This was inverted, arranged with weights suspended from the lower jaw, and "so tipped that the force of gravity would, during

[1] The Dental Cosmos, Vol. xxxviii., p. 484.

[2] The Human Skull used as a Gnatho-dynamometer to Determine the Value of Trituration in the Mastication of Food. Paper read before Union meeting, Washington, 1906.

mastication, give a sliding or triturating motion." The comparative table, appended below, gives the results in pounds obtained by these two investigators.

	Dr. Head's	Dr. Black's
Raw cabbage	16 lbs.	40—60 lbs.
Raw onion	4 "	
Head lettuce	8 "	25—30 "
Radish, whole broke	20—25 lbs	20—25 "
Pieces radish, pulverized	10—25 "	35—40 "
Corned beef	18—22 "	30—35 "
Boiled beef	3 "	
Tongue	1— 2 "	3— 5 "
Lamb chop	16—20 "	
Roast lamb	4 "	
Roast lamb kidney	3 "	
Tenderloin of beefsteak (very tender)	8— 9 "	35—40 "
Sirloin steak	10—20—43 "	
Round of beefsteak, tough	38—42 "	60—80 "
Roast beef	20—35 "	35—50 "
Boiled ham	10—14 "	40—60 "
Broiled ham	10—13 "	
Pork chops	25—30 "	20—25 "
Roast veal	16 "	35—40 "
Veal chops	12 "	
Roast mutton	18—22 "	

Mastication is a voluntary act, but the coördinating mechanism once having been set in motion by the will, it continues reflexly and automatically, and is independent of conscious action. The food, having been passed into the mouth, is carried back to the molar and bicuspid teeth and crushed after the manner already described. The tongue is the principal agent in keeping it between the crushing surfaces. The tonic contraction of the orbicularis oris in the lips and the buccinator in the cheeks opposes the tongue, active action of either occurring when necessary, while within the arch the tongue shifts the food from side to side between the morsal surfaces as may be necessary, the rugæ affording a rough surface upon which it may be rolled. The saliva, which is constantly secreted in the mouth and which flows in greater abundance under the stimulation of the presence of food and of mastication, is mixed with the food. It softens the food, dissolving some of its soluble constituents, adds a digestive ferment, and its mucin assists in agglomerating and lubricating the mass for deglutition. It also lubricates the soft tissues which play about the teeth. During the process of mastication the teeth not only crush the food, but also functionate as organs of exquisite tactile sensibility, giving instant knowledge of the location of the alimentary particle and of its physical consistence.

Deglutition.—After the food has been masticated and mixed with saliva, it is gathered into a bolus upon the tongue, the edges of which are curved upward to form a gutter. The anterior portion, being lifted by its intrinsic muscles and the stylo-glossus, is in contact with the anterior portion of the palatal vault, the rugæ affording here also a roughened surface against which it is placed. The soft palate is then lifted by the levatores palati to touch the posterior wall of the pharynx, which has been bulged forward to meet it by the action of its

superior constrictor. At the same time the funnel-shaped pharynx is brought up by the palato-pharyngeus and the stylo-pharyngeus to cover the mass, which is then shot past the pillars of the fauces by the pressure exerted upon the tongue by the contraction of the mylo-hyoid and of the hyoglossi (Kronecha and Metzger); the opening into the larynx is closed by the contraction of the lateral crico-arytenoids and the constrictors of the glottis, by the elevation of the larynx, and partly by the epiglottis, although the part taken by the latter structure is of small importance. The peristaltic action of the œsophagus then carries the food to the stomach.

THE LOSS OF THE TEETH.

It is beyond the purpose of this work to discuss the causes which result in the loss of the teeth. Suffice it to say on this subject that the absence of the teeth is so frequent an accompaniment of old age as to be looked upon as one of its usual features. An edentulous condition is not the result of natural physiological processes analogous to those by which the accomodation fails from a weakening of the ciliary muscle and a hardening of the crystalline lens, or the hair turns gray in old age from a disappearance of its pigment. The teeth are lost from pathological processes which either receive no treatment or are unsuccessfully treated; from accidental causes; or are removed surgically in the treatment of diseased conditions. Unfortunately it frequently happens that they are lost from these causes before the period of old age.

Effect upon Mastication.—The effect of the loss of the teeth upon the masticatory function may be readily understood since their part in it has been described. As each tooth performs a definite portion of the work of the mechanism, its loss is followed by a definite interference with that work. The loss of one tooth deprives the opposed series of one of its antagonists, and renders it functionally useless at this point. The loss of a tooth also deprives the adjacent teeth of the support of approximal contact. While some teeth are more important than others and their loss is followed by more serious consequences, yet in general, the loss of teeth having antagonists increases proportionately the deficiencies of the apparatus.

The function peculiar to any class of teeth is affected by their loss. When the incisors are missing, the incisive function suffers; when the molars and bicuspids are absent, the trituration of the food is interfered with. The function of the lost teeth is partly taken up by those which remain. The incisors are frequently called upon to perform the work of the molars and bicuspids, a service for which they are in no degree suited, and one which ultimately causes them to be unduly abraded, and also results in an approximation of the jaws distally, and establishes conditions which complicate the subsequent insertion of artificial dentures. The molar and bicuspid teeth remaining on one side of the mouth may

have to perform all the mastication which should have been divided between the two sides. This condition is also followed by unnatural consequences, because the apparatus is designed for symmetrical operation. The usual result is a distortion of the normal relation of the jaws, and a movement of the remaining teeth under the unnatural masticatory force.

The assumption of the whole masticatory function by a portion of the denture may continue satisfactorily for a while, and the digestive process may not suffer, because in the alimentary tract there occurs a large amount of adjustment to the conditions in the mouth. The more slowly the teeth are lost, the more readily will this adjustment take place. The food habit usually alters naturally in the course of the process, articles requiring little trituration or those previously subdivided being utilized in increasing proportion; this being especially true as the period of old age is reached. There is also an alteration in the secretions to harmonize with the changed conditions. Lefoulon has pointed out the compensatory increase in the flow of saliva which takes place at this time.

It is evident however that the metabolic balance must sooner or later be disturbed by the decline of the masticatory apparatus. Oefele[1] has shown that there is a marked failure in the digestion of starches by those who have lost their molar teeth, and Richard[2] has called attention to the fact that in some animals, vegetable particles may go through the alimentary canal practically unchanged, unless their natural protective covering had been broken by the teeth.

When mastication is defective, not only is there a failure to assimilate the food, but since particles of too great size for gastric digestion are swallowed, peristalsis is delayed, fermentation takes place, and pathological processes ensue in the stomach and intestines. The gastritis and enteritis which are frequently observed in edentulous patients give clinical evidence of the truth of this assertion; and the removal of the cause—that is, the restoration of the masticatory function by the insertion of satisfactory artificial dentures, is usually followed by a disappearance of these conditions.

CHANGES IN THE JAWS FOLLOWING THE LOSS OF THE TEETH.

The principal changes which occur in the jaws after the loss of the teeth take place in the alveolar process. This structure is developed with the teeth, furnishes them with support, and is largely resorbed after they are lost. When a tooth of the permanent denture is extracted, its socket in the process of repair is partially filled up with cancellated bone tissue, which in turn becomes covered over with cortical bone tissue and mucous membrane. There is a resorption of the margins of the socket, particularly of those corresponding to the outer and

[1] The Dental Record, Vol. xxv., p. 160.

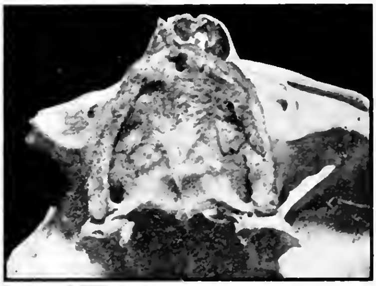
[2] De la prothèse dentaire. Thèsé pour le doctorate en médicine. Paris, 1866.

inner plate, and a general rounding and lowering of the alveolar process, and a loss of contour at this point. This change is repeated each time a tooth is lost, so that after the loss of all the teeth, the alveolar ridge persists in the modified form described. The process of resorp-

Fig. 212

Edentulous upper jaw, showing thin alveolar ridge.

Fig. 213

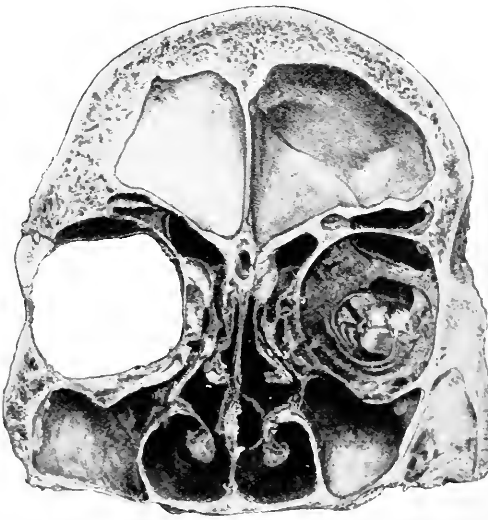


Edentulous upper jaw, showing flat alveolar ridge.

tion differs somewhat in the two jaws and differs in accordance with the conditions which have preceded or attended the loss of the teeth.

When resorption of the margins of the sockets in the condition commonly designated pyorrhea alveolaris has preceded the loss of the teeth,

Fig. 214

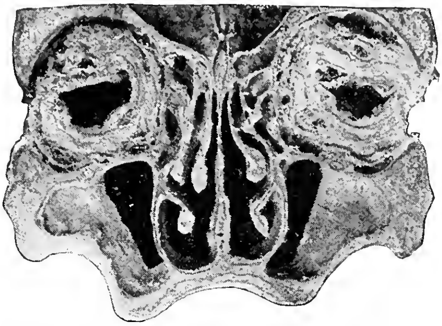


Section showing extreme resorption of the alveolar ridge. (Cryer.)

the alveolar ridge will be found but poorly marked, and the overlying soft tissues which have been the seat of chronic inflammation will be found soft and non-resistant. This furnishes the poorest base for an artificial plate denture.

The Upper Jaw.—After the loss of the teeth the maxilla undergoes change in form and size. Most of the resorption of the alveolar process takes place at the expense of the external plate, the internal plate being modified only as resorption of the top of the ridge proceeds. The resorption of the external portion of the ridge generally occurs progressively. The ridge becomes more rounded, lower, and gradually less pro-

Fig. 215



Section showing considerable resorption of the alveolar ridge. (Cryer.)

nounced. (Fig. 215.) When the alveolar process was originally high and narrow, the resorption of the external plate reduces its thickness and it persists as a thin well-marked ridge. (Figs. 212 and 216.) The ultimate state which the jaw may reach is that in which the whole roof of the mouth is flat. (Figs. 213 and 214.) This occurs only in unusual cases. In extreme cases there is a falling in of the cartilaginous septum of the nose from the resorption anteriorly. (Fig. 217.)

Fig. 216

Profile view of edentulous upper jaw, showing thin alveolar ridge.

Fig. 217

Profile view of edentulous upper jaw, showing considerable resorption.

The palatal vault is the part of the jaw in which the least change occurs, as the resorption takes place on the external side of the ridge and on top. This may be noted by reference to Fig. 213, which shows an edentulous jaw. When this is compared with one with the full complement of teeth (Fig. 187), reference to the anterior palatine foramen, the position of which does not change after the loss of the teeth, and which in the living subject corresponds approximately to the incisive

pad of the rugæ, will show that most of the resorption has occurred external to this point.

The extreme degrees of resorption of the process are caused by stimulation of the giant cells from pressure in masticating the food directly upon the gums, from ill-fitting dentures, or from other causes. Properly fitting artificial dentures prevent, in a great measure, this resorption. Artificial dentures arranged with occlusion at one point only are frequently productive of a localized resorption of the process, which complicates the successful fitting of new dentures. One of the most commonly observed cases of this sort is that in which a full upper plate denture is antagonized only by the six or eight lower natural anterior teeth, there being no teeth posterior to this point, resorption of the alveolar process of the maxilla in front occurring as the result of the undue pressure upon it.

The Lower Jaw.—The changes occurring in the alveolar process of the lower jaw are similar to those which occur in the upper. In discussing the phenomena of growth and resorption in the mandible, the

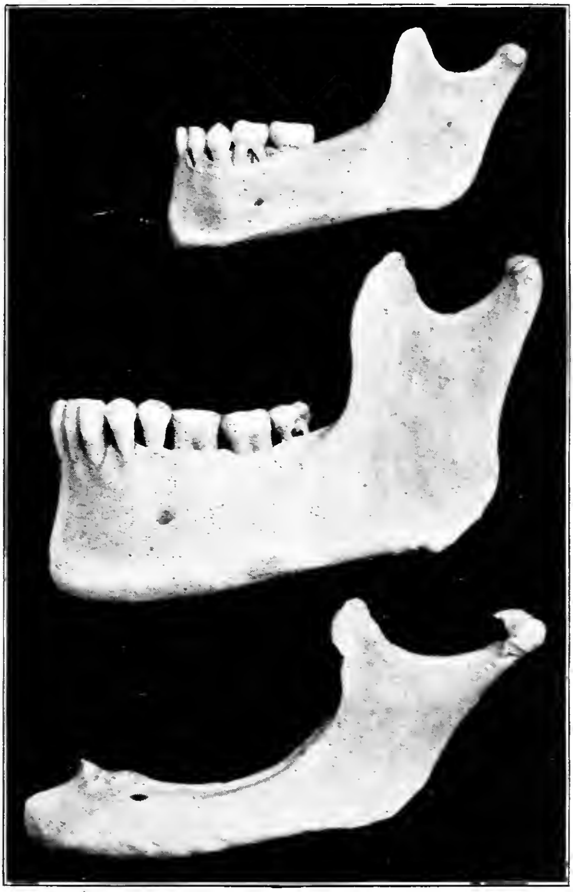
Fig. 218

Internal view of the half of an edentulous mandible, showing character of the resorption of the alveolar process. There is considerable resorption posteriorly, but very little in the anterior portion of the process, as the teeth have been lost here only a short time.

character and extent of these changes are well described by Sir John Tomes as follows: "In the great majority of specimens a small foramen is situated in the median line immediately above the upper pair of tubercles (genial), and when present, this may be selected as a point from which to take * * * * dimensions. Unfortunately it is sometimes wanting or is represented by a similar aperture below the spinæ mentales. In a series of jaws taken from very old subjects in whom the teeth had been lost and the alveolar process had been absorbed the foramen holds to its original position. If these specimens are subjected to measurement we find that this aperture is within $\frac{1}{12}$ to $\frac{3}{12}$ of an inch of the alveolar margin, showing a loss in the oldest jaw of $\frac{9}{12}$ while it is separated from the lower border of the jaw by $\frac{6}{12}$ of an inch, the loss in this direction being inappreciable." (Fig. 218.) The

alveolar plates of the mandible, according to Cryer, resorb more evenly than in the upper jaw, usually a small ridge remaining to indicate the position of the former process and teeth. The external oblique line which descends from the anterior margin of the coronoid process, is, always external to the location of the former alveolar ridge. In cases

Fig. 219



A

B

C

Specimens showing the angle formed by the ramus and the body of the mandible; A, at the time of completion of the temporary denture; B, in adult life; C, in old age. (From a photograph of specimens in the Wistar Institute of Anatomy.)

of extreme resorption the ridge is entirely obliterated, and commonly there is less ridge in the lower jaw than in the upper.

Only slight change occurs in the body of the bone, as has been mentioned above. A noticeable change, however, occurs at the angle of the jaw. Fig. 219 illustrates the cycle of change occurring in this region between the time of the completion of the temporary denture and old age. Since the vertical distance between the jaws is increased in adult life to accommodate the permanent denture, there must necessarily be a

change in the angle of the jaw to make this possible. The average angle made by the body and ramus of the jaw in an adult is about 120°. While the natural teeth are in position, no change occurs in the relation of the jaws except a slight approximation due to the wear of the teeth. If the teeth remained there would be no appreciable alteration of the

Fig. 220

Skull showing relation of edentulous jaws: profile view. (From photograph of a specimen in the collection of Dr. M. H. Cryer.)

Fig. 221

Skull showing relation of edentulous jaws; views from below. From photograph of a specimen in the collection of Dr. M. H. Cryer.)

angle of the jaw. As age advances and as the back teeth are lost, the powerful traction exerted by the muscular apparatus, upon the anatomical angle of the jaw, the forward end of the jaw being in occlusion through the anterior teeth, causes a flattening of the angle and at the same time the symphysis is carried forward. After all the teeth are lost this becomes still more evident. Slight change occurs also at

the condyle where a general flattening takes place. There is also an alteration of the glenoid fossa corresponding to this. Its pronounced margin is lost and it becomes in general more flattened. (Fig. 175 D and E.)

The Relation of the Jaws.—"As the resorption of the alveolar process goes on, the vertical distance between the body of the lower jaw and that of the upper is lessened while the natural difference in their width is increased. The area of the upper jaw becomes smaller in proportion to that of the lower; the axes of the mandible extending further outward. In the endeavor to close the jaws under these circumstances, the lower is projected further forward as it rises to meet the upper, until in extreme cases, it may pass absolutely outside of the upper.[1]" Figs. 220 and 221 give two views of an edentulous skull and show the relations of the jaws.

VOICE AND SPEECH.

Voice.—Voice is the audible sound originating in the vibrations of the vocal cords and reinforced by the resonance of air cavities situated in the head and chest. The apparatus by which it is produced consists of (1) the lungs, chest walls, and muscles of expiration, which furnish the motive power; (2) the larnyx, in which are situated the vocal cords; and (3) the chest cavity below, and pharynx, mouth and nose above, which constitute the resonating chambers. When the air is forced out of the lungs by the contraction of the chest muscles and at the same time the vocal cords are approximated and made tense, their edges are set in motion and a sound is emitted. The cords themselves are capable of producing only a feeble sound,[2] but when they vibrate close to self-sounding bodies as the air in the cavities above mentioned, this air is thrown into sympathetic vibration and the volume and character of the original sound are altered. The sound made by the cords is not a simple musical tone but is a complex "note made up of a fundamental tone combined with upper partial tones," overtones, or harmonics, of which as many as sixteen in some instances accompany the fundamental.[3] When the air contained in the resonant cavities is thrown into vibration, it is capable of emitting a musical note, the pitch of which depends either upon the size of the cavity or upon the size of the opening by which it communicates with the external air. The larger the cavity or the smaller its opening, the lower will be the pitch and vice-versa. The resonant cavities reinforce either the fundamental tone, or the harmonic of the laryngeal sound, which corresponds to the pitch to which they are tuned, so that alterations in their shape largely determine what is known as the quality of the voice.

The voice possesses in common with other musical sounds three characteristics—(1) pitch, (2) loudness, and (3) quality. The pitch is determined by the tension of the vocal cords; the tighter they are stretched the higher will be the pitch. Loudness is proportional to the strength of the expiratory blast, and is also related to the resonance

[1] M. H. Cryer. Internal Anatomy of the Face. p. 168

[2] Sewall: American Text Book of Physiology, Vol. II., p. 421.

[3] Helmholtz—Quoted by Sewall: American Text Book of Physiology Vol. II, p. 435.

of the cavities above and below the larynx. The quality of the voice is dependent upon the character or form of the sound wave, and is related to the number and relative intensity of the overtones or harmonics which accompany the fundamental tone. The form of the wave is determined by the state of tension of the vocal cords, and by the form and size of the air cavities, which act as the resonating chambers. The air cavities, whose pitch may be changed at will, contribute by their resonance, now to reinforce this tone and now that, so that any overtone or the fundamental may be intensified by change in the shape of the resonant cavities.

The æsthetic value of a human voice depends upon the number, character, and relative intensity of the overtones which accompany its fundamental tone. This tone-quality is determined by the power of adjustment of the larynx, in which the tones are produced, and by the precision of the muscular adjustments regulating the resonant pitch of the air cavities in which the tones are accentuated. The capability of the larynx is the more important of these factors, but it is evident that ability to correctly attune the resonating chambers is a necessary adjunct.

The mouth is one of the most important of these resonant cavities. Its form is altered by the depression of the mandible and by the movements of the tongue. The soft palate also assists in this process, its chief function, however, being to separate the mouth and nose cavities. Increase in the size of the mouth causes a corresponding lowering of its pitch. The lips serve to increase or diminish the opening communicating with the outside air; the larger the opening, the higher will be the fundamental note of the cavity; the smaller the opening, the lower will be the note.

The pharynx is changed in shape by the rising and falling of the larynx, while the resonance of the nasal chambers and the air cells communicating therewith cannot be altered at will. The resonance of these cavities may be controlled only as they are added to or separated from the mouth space by the action of the soft palate and tongue.

Those portions of the air cavities which are uninfluenced by muscular action are but passive factors in regulating their resonance. It is by the adjustment to these of the soft and moveable parts that variations in their resonance are produced. Therefore the change in the fixed parts of the mouth caused by the loss of the teeth, necessitates a change in the muscular adjustments, and requires new co-ordinations on the part of the tongue. The lips and cheeks, which are no longer supported by the teeth, fall in and complicate the process of adjustment. This change in the fixed portion of the mouth is almost always succeeded by changes in the qualities of the voice, although the speaking voice is altered less than the singing voice, in which more precise muscular co-ordination is required.

Speech.—Articulate speech by means of which man communicates his thoughts, has for a long time been divided by scholars into vowel sounds, or those produced in the larynx and modified by the position of the various mouth parts, and consonant sounds, which are noises ac-

companying the other sounds and are largely made in the mouth. Language consists in the regular progression of these sounds, which either singly or in combination represent ideas.

Vowels.—The vowels are the true laryngeal sounds, originating in the vibration of the vocal cords and determined by their state of tension and by the peculiar resonance of the pharynx, nose and mouth. For any given vowel the posture of the mouth parts is the same, that is, this cavity is tuned to a definite pitch, the difference in the actual pitch of the vowel being determined by the tension of the vocal cords and by the size of the pharynx. In tuning the cavity for the sounding of *ah* (*father*), *o* (*own*), and *oo* (*shoot*), the tongue does not touch the palatal vault, but in *a* (*ate*) and *e* (*met*), its sides touch the molar and bicuspid teeth and adjoining alveolar process. The vowels are closely related, for the position of the mouth parts for one vowel easily changes to that for another. It is evident therefore that the changed conditions of the mouth incident to the loss of the teeth require new muscular adjustments to enable the mouth cavity to be tuned to the proper pitch for each vowel.

Consonants.—In the production of most of the consonant sounds, a current of air is interrupted or stopped at some point during its exit from the lungs, the noise resulting therefrom being the consonant sound. Some consonants however may be sounded only in conjunction with a vowel, in which case the consonant is only a superadded noise to the laryngeal sound and is due to the peculiar resonance imparted by the mouth and nose cavities when they are properly disposed for the formation of the consonant. In other consonants the sound originates in the mouth, from vibration of the mouth parts caused by an incomplete obstruction to the air current, while in others there is an explosive sound due to the sudden stoppage or starting of the air current.

The following table[1] gives a classification of the consonants according to the place at which they are formed:

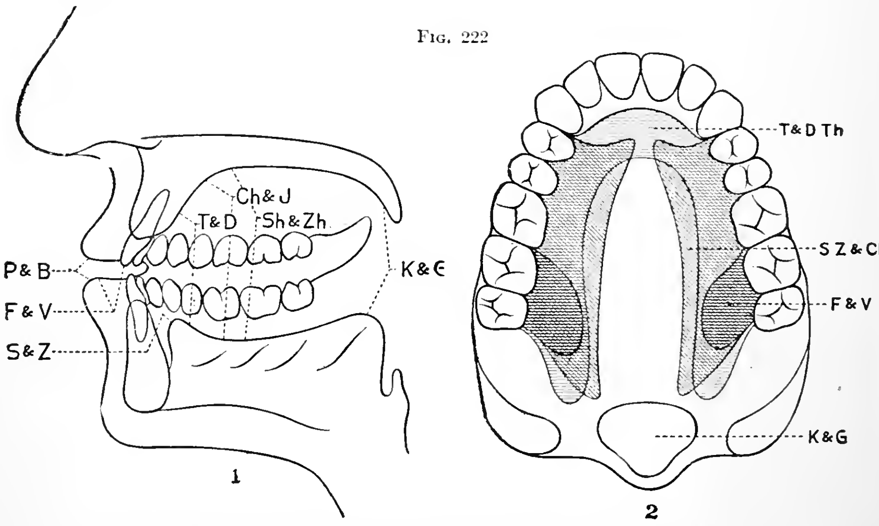
Place of articulation	Oral				Nasal
	Momentary		Continuous		Continuous
	Surds without voice	Sonants with voice	Surds without voice	Surds with voice	Sonants with voice
Lips	p	b	-----	w	m
Lips and teeth	----	----	f	v	
Tongue and teeth	----	----	th (in)	th (y)	
Tongue and hard palate (forward)	t	d	s, c (ity)	z, r	n
Tongue and hard palate (back)	ch	j	sh	z, r	
Tongue, hard palate and soft	-----	----	----	y, l	
Tongue and soft palate	k, c (at)	g	----	----	ng
Various places	h				

[1] Sewall: American Text Book of Physiology, Vol II., p. 437.

A careful study of this table will show that the factors determining any given consonant are the strength of the expiratory blast, the presence or absence of voice, and the position of the mouth parts.

Mechanism of the Production of the Consonant Sounds.—In the formation of the P and B sounds, the air blast meets no interference in the mouth because of a narrowing of the channel, but is interrupted at the lips by their sudden opening or closure (Fig. 222). In P there is greater air pressure and greater suddenness in the stoppage or starting of the current. In K and G also the channel is unaltered, stoppage of the blast occurring at the posterior portion of the palatal vault by the application of the base of the tongue to the soft palate. In G the air pressure is not so great as in K and the tongue touches a larger area. In L and M and NG the channel is not changed by the application of the sides of the tongue to the vault. In L the tip of the tongue touches the process back of the incisors, while the air current divides and escapes around its sides. In M and NG the air current escapes through the nose.

Fig. 222



1. Diagrammatic drawing showing place of articulation of the consonant sounds. 2. Drawing showing contact with the tongue with molars and bicuspids in the formation of certain consonants.

In all the other consonant sounds except H, an air channel is made by means of the tongue to direct the blast either upon some point at which there is a partial obstruction or upon some point at which it is stopped. For this purpose the tongue is applied to the sides of the palatal vault touching the molar and bicuspid teeth and the process adjoining, and forms a sort of gutter through which the air is expelled. The position and area of this contact varies with the different letters. In the formation of T and D the lips are open and the tongue touches the alveolar border with its tips and sides, the tip being depressed as the current of air is ejected. In T the pressure of the blast is greater

than in D. In CH and J the tongue is pressed upon the alveolar border at its sides and tip, and the air current is forced between the tip and the anterior portion of the palate. The noise is made between the palate and the tip of the tongue.

In N the oral cavity is closed by the placing of the tip of the tongue against the palate instead of by the closure of the lips as in M. The air escapes through the nose in these consonants, and a peculiar nasal resonance is added to the voice sound.

In articulating the sounds S, Z, Th, Sh, Zh, F and V the air current produces a blowing sound due to its impingement upon some portion of the channel. In the F and V sounds the lower lip is in contact with the incisal edges of the upper teeth, the tip of the tongue being pressed against the lower incisors, while its sides touch the last molar teeth and process, and guide the air between the lip and teeth. In the formation of S the air is forced past an incomplete obstruction, the edges of the adjacent tissues being set in vibration by the current. The teeth are almost in contact, the lips slightly open, the tongue curls upon the sides to touch the molar and bicuspid teeth as far forward as the canine and the adjoining palatal vault, leaving a narrow opening in front for the egress of the air. The end of the tongue touches the lower incisor teeth, and the sound is caused by the impingement of the air upon the edges of the closed teeth. Z and C (soft as before E and I) are made in the same way, the difference in the intensity of the blast differentiating them.

In Sh and Zh the air is forced by two obstructions, one caused by the arching up of the tongue to nearly touch the palate, the other caused exactly as in S. X is a combination of the S and K sounds.

In Th the tip of the tongue is placed between the upper and lower incisors, the air channel being formed by its sides as in some other consonants. The edges of the upper teeth are set in vibration by the air.

"Lingual R" is produced by having the sides of the tongue in contact with the molar teeth and palate, to direct the current upon the tip of the tongue which is curved upward toward the palate and thrown into irregular vibrations by the blast.

In H[1] the air current meets no obstruction in the mouth, the vibrations producing the sound of the consonant being those of the separated vocal cords. As W is a combination of H and V, its production needs no separate description.

The above description is that of the method of producing these sounds when the apparatus is in its normal state. A change in any of the parts concerned in this process must result in an interference with the correct articulation of the sounds.

It will be seen that so far as the part taken by the mouth in the production of these sounds is concerned, interference with the mechanism by which the air channel for a given consonant is formed, or with that by which the air is obstructed or stopped, must necessarily be followed

[1] Sewall, op. cit., p. 438.

by an interference with the proper articulation of that sound. The channel is formed by the adjustment of the tongue to the teeth and the sides of the palatal vault, and the obstructions and interruptions are made through contact of the tongue with the teeth, or the hard or soft palate, or of the lips with each other, or with the teeth. The loss of the teeth, the resorption of the process, which alters the form of the palatal vault, and the change in the relation of the jaws must all have a serious influence upon articulation. This is also complicated by the falling in of the lips and cheeks which are supported by the teeth and alveolar process. The tongue is the principal organ of articulation and may learn to accommodate itself greatly to the change in the parts to which it is applied in the production of the sounds, but it is evident in some instances that satisfactory adjustment cannot take place.

The loss of the incisor teeth affects the sounds articulated in this region. When a single upper incisor is missing, at this point there is an escape of air in some of the co-ordinations in which it should be confined, and the sound of S seems to be made. One of the commonest defects from absence of the incisors is in the formation of Th, the air escaping and giving an S sound instead. When the upper incisors are lost, the F and V sounds are difficult to make, the lower lip having to accommodate itself to the alveolar process or to the upper lip, and the sound approximating P or B. In some cases the S sound itself is difficult, especially if both upper and lower incisors are missing, Sh and Zh being similarly affected by this condition. T and D are also sometimes difficult to enunciate, especially if there has been much resorption of the alveolar process against which the tip of the tongue presses.

As the molar and bicuspid teeth and adjoining process form part of the lateral walls of the air channel in the enunciation of a number of consonants, deficiencies here affect speech also. The tongue cannot close the sides of the air passage, and the current escapes into the cheeks. T, D, Ch, T, Th, Sh, Zh, S, Z and C are principally affected and especially so when followed by the vowels A or E, contact of the tongue with the sides of the vault being also necessary in the making of these vowel sounds. F and V may occasionally suffer, and sometimes the tongue cannot shut off the air in N and it escapes into the mouth, destroying the full nasal resonance characteristic of this letter.

THE EXPRESSION OF IDEAS AND EMOTIONS BY THE FACE.

The expression of thought and feeling in man is accomplished for the most part in three ways: by gesture, by speech and by writing. Speech is the means in most universal use, gesture being chiefly employed to supplement language, while the utility of writing is naturally restricted because of the conditions required for its performance. Beside containing the organs of articulate speech, the face performs expressional services which are not included under any of the above headings. These consist of the movements of associated groups of facial muscles which occur simultaneous with the existence of cer-

tain emotions or which express some idea of the mind. The muscular movements and the effect they produce upon the countenance are the accompaniment and the outward manifestation of the psychic state. According to Mantegazza[1] they have two diverse functions; they may replace or complete language, or they may defend the nerve centres or the parts of the body against dangers of different kinds. The forms of facial expression are the same throughout the world[2] and are too familiar to require description.

As one of the most mobile features of the face, the mouth participates largely in its expressive movements. The loss of the teeth interferes with the performance of this function of the mouth; it is proposed therefore to give a brief account of the mechanism by which the facial movements are effected, to point out the part taken by the mouth, and to indicate in what way the absence of the teeth interferes with the muscular action.

Before discussing this mechanism, however, it will be necessary to clearly differentiate between the terms "facial expression" and "the expressive movements of the face." The former alludes to the countenance, its form, contours, surface, muscles—in short, its anatomy; while the latter refers to the contraction of the facial muscles which produces the movements expressive of ideas and emotions. Facial expression will be treated under a separate heading.

The Facial Mechanism of Expression.—The mechanism of the expressional movements of the face consists of (1) a bony framework, the facial skeleton; (2) the muscular apparatus, technically referred to as the muscles of expression; (3) the connective tissue, fat, and overlying integument which complete the face.

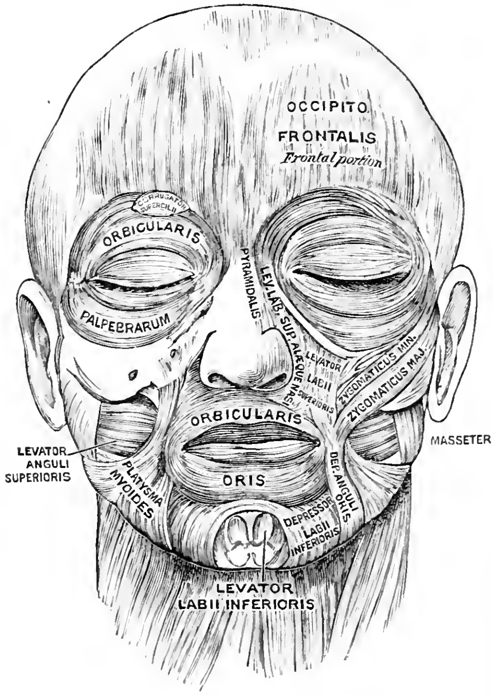
The facial portion of the skull gives form to the countenance. It also contains some of the special sense organs which are features of the face, and it affords points of origin for the muscles of expression. The skin of the face is very thin, elastic, and loosely adherent to the underlying structures. Over the nose, however, it closely adheres to the bone and cartilage, and over the chin it is closely united to the mandible through the medium of the intervening tissue. The superficial fascia underlying the skin is intimately united to it. It is very loose and cellullar, contains large amounts of fat, and permits great mobility of the integument. The facial muscles, illustrated in Fig. 223, are numerous. For the most part they are superficial and are closely attached to the under surface of the skin. This arrangement permits them to produce in the skin the folds and depressions associated with their movements.

The facial muscles of expression (Fig. 223) may be divided into three groups—those centering about the eye, about the ala of the nose, and about the mouth. They are all concerned in the expressive movements of the face, but as we are interested only in the part played by the mouth, we shall discuss only the muscles operating in this region.

[1] Physiognomy and Expression, p. 80.
[2] Charles Darwin: The Expression of the Emotions in Man and Animals.

The orbicularis oris which surrounds the aperture of the mouth is the common meeting ground of the muscles of this group. It consists of two portions—the labial, which occupies the red border of the lip, and is narrow, thick, and regular, and the facial, which is wider and thinner, and spreads out into a wide band just beneath the skin around the oral orifice. Joining these two portions are a large number of muscular fibres which run antero-posteriorly from the skin on the outside to the mucous membrane on the inside. This muscle constitutes the larger portion of the substance of the lips, and gives them their

Fig. 223.



The facial muscles of expression.

fleshy characteristics. The labial portion of the orbicularis has no attachment to the bone beneath it. At the angle of the mouth it is deeply situated and intimately connected with the buccinator muscle, decussating fibres of which pass above and below this point to be lost in the upper and lower lip. The facial portion has only three small bony attachments on each side. The largest of these are the naso-labial slips, which are slender bands passing up to be attached to the anterior nasal spines, and which correspond on the external surface to the philtrum. Two other slips are attached to the incisive fossæ in the upper jaw, and two smaller slips are inserted in the incisive fossæ of the mandible. The orbicularis is not truly speaking a sphinc-

ter muscle as that term is applied to orificial muscles of other parts of the body. It is doubtful if any of its fibres are continuous around the aperture. When the labial portion alone contracts, it everts the lips and diminishes the width of the mouth. The facial portion serves to press the lips against the teeth and adjoining process. Its two portions oppose the other mouth muscles.

Arranged radially about the mouth and united to the orbicularis are the other muscles of this group. They are the levator labii superioris alæque nasi, the levator labii superioris proprius, the levator anguli oris, the zygomaticus major, the zygomaticus minor, the depressor anguli oris, the depressor labii inferioris, the levator labii inferioris and the risorius.

The points of origin from the bones of the face and the points of attachment to the orbicularis indicate the line of action of these muscles. The anterior teeth and alveolar process form a base upon which the tissues of the lips may be moved by them. The mucous membrane is lubricated by the saliva and permits an easy sliding of the lips upon the underlying structures. The canine tooth and eminence are especially important as a base of support for these movements. They underlie the corner of the mouth and afford a prominence over which the lips may be pulled by the muscles attached to the angle of the mouth.

The action of the individual muscles constituting this group has been carefully investigated by Duchenne[1] who has given a detailed account of their effect upon the countenance. It is beside the purpose of this work to discuss the significance of these movements in great detail. The reader is referred to the literature on the subject for more minute particulars. In order, however, that the reader may understand the usual meaning of the contraction of these separate muscles the following account of their action is appended.

The levator labii superioris alæquæ nasi is the principal muscle in the expression of contempt and disdain. It dilates the nostrils and raises the upper lip and draws it slightly forward, and with the other levator muscles increases the prominence of the cheek below the orbit. It helps to develop the naso-labial fold. When it contracts with the other levator muscles of the upper lip, an appearance of sadness and grief is produced. The levator anguli oris draws up the angle of the mouth, pushing up the lower eyelid as in crying. The zygomaticus major is the muscle of joy or laughter. It draws the corner of the mouth backward and a little upward. The zygomaticus minor assists in drawing upward and outward and backward the outer corner of the upper lip but not the corner of the mouth. It produces an expression of sadness. The depressor anguli oris (triangularis menti) draws the corner of the mouth backward and downward and is necessary in the expression of sadness or grief. The depressor labii inferioris (quadratus menti) draws the lower half of the lower lip downward and a little outward. With its fellow of the other side it draws the lip directly down and slightly

[1] Mecanisme de la physiognomie humaine ou analyse électro-physiologique de l'expression des passions. Paris, 1876.

everts it. It is used in the expression of irony. The levator labii inferioris acts with its fellow in raising the lower lip. It protrudes the chin, as in pouting, and produces dimples in the skin of the chin. It is used in the expression of doubt and disdain, especially when aided by the triangularis menti. The risorius or muscle of Santorini is ordinarily spoken of as the smiling muscle. It draws the corner of the mouth directly backward and produces what is known as the "sardonic grin." The platysma myoides muscle must be mentioned in this group because a few of its fibres really constitute the risorius muscle. It is attached above mainly to the subcutaneous periosteum of the lower jaw from the symphysis backward. Its middle and anterior parts assist in depressing the jaw, while its posterior or lower parts are largely attached to the corner of the mouth, and act to draw the lower lip and angle of the mouth downward and backward, and this assists in the expression of grief and fear.

It will be noted that the buccal orifice and its surroundings are molded to the teeth and alveolar process by the tonicity of the facial portion of the orbicularis and the muscles which connect with it. The loss of the teeth and the subsequent resorption of the process are followed by a falling in of these tissues. Inasmuch as they are no longer supported upon a solid basis, their movement is restricted in amount and in direction. The muscles which serve to carry the lips upward or downward are not so much hampered in their action as those which draw the lips and the mouth backward. This limitation is more particularly due to the absence of the canine tooth and its eminence than to anything else. All expressive movements of the face in which part is taken by the oral muscles are limited after the teeth have been lost.

In a succeeding chapter the restoration of the various functions of the face and mouth by artificial dentures will be discussed. It is desirable that the student should be familiar with the effect of the contraction of each of the muscles of expression, in order that he may not impart to the countenance any unnatural look caused by too great fulness of the plate at any point. A denture which produces the same effect upon the countenance which the contraction of any muscle or muscles causes will impart to that countenance the expression associated with the contraction of the muscles so distorted. This will be discussed more in detail in Chapter XII.

FACIAL EXPRESSION.

The human countenance is made up of the features of the face. Facial expression may be regarded as consisting; first, of the features of the face, which are considered from a purely anatomical standpoint, and are the result of natural endowment; and second, of a certain impress made upon these features by the thoughts and actions of the individual. The natural endowment of the face is the result of hereditary influences, principally those of race and parentage. As the individual grows and develops after birth, the impress of thought, of action and of experience is made upon the countenance. The frequent use of certain of

the muscles of expression, attendant upon the existence of some thought or emotion, cultivates a tonicity of those muscles, and develops, folds in the integument of the face, which impart a certain cast or expression to the countenance. These two influences taken together, the one prenatal and determining the anatomical form of the features the other postnatal and influencing the expression—establish the character and indentity of a face. In discussing the human countenance Mantegazza gives five verdicts which may be taken upon it; physiological, ethnological, æsthetic, moral and intellectual. The ethnological and æsthetic are based solely upon anatomical characteristics, while the physiological, moral and intellectual are more largely founded upon expression. The term facial expression in its broadest sense is intended to include all the data upon which these several judgments are based. In this chapter it will be used with that meaning.

Facial expression is altered by the loss of the teeth and alveolar process in several ways:

First, Absence of the Teeth.—The teeth are displayed in the movements of the lip in laughing, in smiling and in speaking. Cigrand[1] says, "Artists tell us that when patients speak words as "at" or "ate" with the short or long sound of *a*, the lips should disclose about one-half of the labial surface of the anterior teeth, upper and lower, while with words having the long sound of *o*, as in "oral" or "open" the lips should hide the teeth to their edges." A larger proportion of the denture is displayed in smiling or in laughter. The relation of the lips and the anterior teeth during these acts constitutes one of their chief elements of beauty, and it is during their performance that a beautiful or unsightly denture imparts beauty or the reverse to the countenance.

Second, Changes of Contour.—The alteration of the contour of the mouth and lips by the loss of the teeth is characteristic. While it is less marked in those of the lymphatic temperament whose short teeth and process underlie lips which are thick and sufficiently rigid to undergo little change after the teeth are lost, yet in the nervous temperament where the lips are thin and require support from the teeth, the alteration in appearance is striking. The changes consist of alterations in the contours of the lips and in their relations. The lips fall inward instead of inclining outward as they do when supported by the teeth. The proportion of mucous membrane which is displayed is diminished. The line of separation between the lips, which may be an element of great beauty in a mouth becomes changed, being altered in most instances from a graceful curve to a characterless straight line. The corners of the mouth, which are supported mainly by the canines, droop, and an expression of weakness is imparted to the face. There is a disappearance of the sulcus mento-labialis, which is formed at the highest point of attachment of the soft tissues of the chin, when the

[1] Facial Guide Lines as Taught by Artists and Sculptors. Paper read before the Fourth International Dental Congress, 1904.

lower lip is supported and slightly everted by the teeth (Figs. 225 and 227).

Third, Changes in the Surface.—The changes which occur in the surface are the obliteration of some of the normal folds in the skin and the establishment of additional ones. Before discussing, however, those which result from the loss of the teeth, it will be necessary to point out those which result from old age, in order that no confusion between the two shall arise. The changes which ensue in old age are the result of two conditions: the absorption of the fat contained in the substance of the lips and cheeks, and the atrophic changes which occur in the skin. These result in the obliteration of contours at points supported by cushions of fat and in the establishment of wrinkles in the

Fig. 224

Photograph showing the wrinkles commonly observed in old age.

skin at points in the line of frequent muscular action. Normally there are masses of fat located in the hollow of the cheek around the buccinator and zygomatic muscles. There is usually also some beneath the levator labii superioris muscle and some at the symphysis of the lower jaw. These may be absorbed early in life because of defective nutrition. They are frequently absorbed after middle life in certain temperaments, notably the nervous. In the sanguine or lymphatic they are more likely to persist through old age.

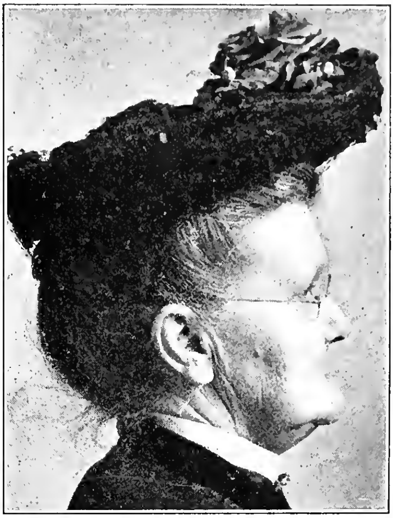
In most individuals past forty, wrinkles of the skin are apt to be established, although as is true in the case of the absorption of the fat, they are likely to appear earlier in a nervous face than in that of other temperaments. Camper has called attention to the fact that they are established at right angles to the line of muscular action. Those normally seen in an individual after forty are the transverse wrinkles of the forehead, vertical wrinkles of the forehead, crow's feet or wrinkles at the external canthus of the eye, the naso-labial fold, which extends

downward and outward into the cheek from the base of the ala of the nose, and the genio-mental wrinkles, extending from the cheeks to the chin (Fig. 224).

Fig. 225

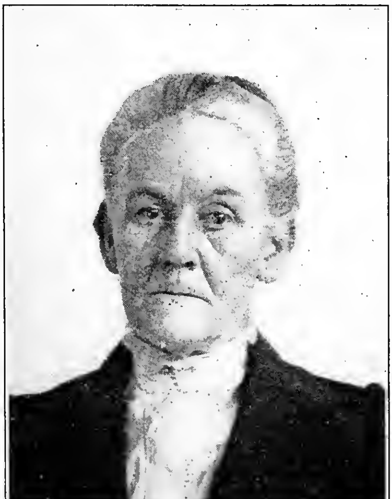
Photograph showing effect of the loss of the teeth upon the mouth, and the wrinkles established thereby.

Fig. 226



Photograph showing the effects of the loss of the teeth upon the profile.

Fig. 227



Photograph showing effect of the loss of tne teeth. Front view of patient in Fig. 228.

Fig. 228

Photograph showing the effect of the loss of the teeth upon the profile.

The loss of the teeth is followed by additional changes in the countenance. The naso-labial fold is accentuated because the upper lip falls in, and frequently becomes two lines, one of which descends from

the ala of the nose to the corner of the mouth (Fig. 225). The philtrum is usually obliterated (Fig. 227). This is due principally to the increase of the sphincter action of the orbicularis, which becomes necessary to keep the mouth closed in order to confine the saliva and food. Usually a groove is established extending from the corner of the mouth in the direction of the chin. In addition to these, small wrinkles placed radially to the oral orifice are established. While these last normally exist in old people, they are much accentuated when teeth are lost because of the marked sphincter action of the orbicularis above alluded to.

Fourth, Changes in the Relation ot the Jaws.—The removal of the points of contact between the jaws results in their approximation. This is attended by a shortening of the soft tissues extending between the two; the muscles and connective tissues being actually decreased in length. As far as the lines of the face are concerned, this effect is particularly noticed in the decreased distance between the nose and the chin. In some instances this effect is marked, the nose and the chin coming so close together, that a characteristic deformity is noticed.

Fifth, Alteration of the Profile.—This is always changed to a greater or less extent. In those cases in which only a small amount of absorption of the alveolar process has occurred, there is only a flattening of the mouth (Fig. 228), while in others the falling in of the lips may be very marked (Fig. 226).

Sixth, Alteration of Expression.—From what has been said concerning facial expression, or that which gives character and identity to the countenance, it must be seen that a condition which is succeeded by so pronounced a change in the features must greatly alter the characteristic expression of a face. One has but to remember the striking change in appearance which has succeeded the extraction of all of the teeth of an acquaintance to appreciate how marked an effect it has upon this means of identification.

CHAPTER V.

THE HUMAN DENTAL MECHANISM AS MODIFIED BY TEMPERAMENT, AGE, AND USE.

By A. H. Thompson, D.D.S., and Charles R. Turner, D.D.S., M.D.

The functional relations of the human denture having been discussed in the preceding chapter, it is proposed in this to treat of those considerations relative to its appearance which are important from the standpoint of dental prosthesis. Artificial dentures are required not only to restore the functions of the natural organs which they substitute, but they must also restore as far as possible the former appearance of the mouth and face.

In nature there is a certain harmony in the various physical characteristics of each individual. There is, for instance, a pleasing proportion in the various parts of the body, and while this proportion varies somewhat among individuals, as they are not all constructed upon the same physical plan, normally these variations occur within fairly well-defined limits, and a marked departure from the plan is at once recognizable as abnormal. The size and shape of the teeth bear in general a certain ratio to the size and shape of the body, or more especially to the size and shape of the head or face, but this is by no means fixed and varies somewhat within the limits of the normal. The mensural proportions of the teeth of different individuals differ vastly, but for the most part they correspond to the bodily dimensions of the individuals owning them. This is also true of their surface form and contours, which similarly correspond to these characteristics of the physique of their owners. There is also a general relation between the color of the teeth and that of the other pigmented tissues of the body.

While this harmonious correspondence between the physical characteristics of the teeth and those of the body is not absolutely universal, it is the general rule, and any departure from it marks the individual as unusual. This bodily harmony is taken as the basis for the selection of teeth in dental prosthesis. Familiarity, therefore, with the physical characteristics of the teeth and of the body and their mutual association is necessary to a judicious selection of artificial teeth to replace the natural ones. With a view to acquainting the student with this, the dental apparatus in its relation to the general physique and the characteristics of each will be discussed in this chapter. The denture will be described from the standpoint of its natural endowment first; that is to say, its variations in the various temperamental types of mankind. Secondly, the changes which occur in it under the influence of age and use will be described.

TEMPERAMENT.

Temperament according to Flagg is a term used to express differences in the mental and physical constitution of individuals. It has been used with this designation since the days of Hippocrates, the earliest systematic writer upon the subject. It is an attempt at the classification of mankind according to his physical characteristics, and has as its basis the relative proportion of his mechanical, nutritive and nervous systems, and the relative energy of the various functions of the body. "Each temperament is the result as well as the indication of the preponderence of one or another of these systems and of their relative functional activity."

Despite the antiquity of this classification it is commonly utilized in dental prosthesis at the present time for lack of a better. Descriptive anthropology and ethnology have not as yet presented a classification of the physical attributes of man which is a satisfactory substitute for that according to temperament. Ethnic peculiarities are sufficiently fixed to identify individuals whose racial characteristics are not mixed, but pure races exist in so few quarters of the globe that this basis of classification is valueless and a more fundamental one is necessary.

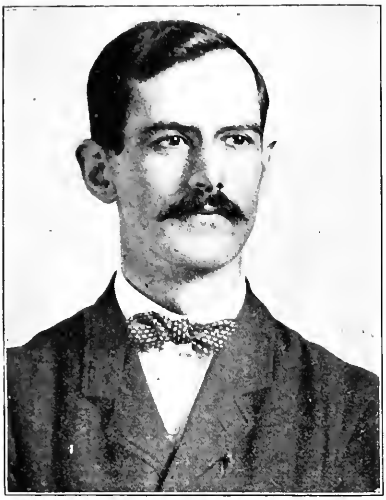
In its ordinary use temperament refers equally to mental and physical attributes. It does not divide mankind into well-marked natural groups which may be distinguished anatomically, but it offers groups of associated physical characteristics, the possession of a majority of which by an individual assigns him to that group. When the predominating temperament of an individual has been determined according to this plan as a preliminary to the restoration of lost parts like the teeth, the result will be harmonious if these are selected to accord with the physical characteristics of that temperament.

According to the present generally accepted classification there are four fundamental divisions of the temperaments. The bilious, in which there is marked activity in the function of the liver; the sanguine, in which the circulatory system is most prominent; the nervous, characterized by a highly developed central nervous system; and the lymphatic, in which the lymphatic system has a preponderating influence.

The following is a description of the general mental and physical characteristics of the basal temperaments. and while these are to be considered chiefly from the physical standpoint, the mental attributes are appended for assistance in diagnosis.

The Bilious Temperament. (Fig. 229.)—*Physical characteristics:* the pulse is hard and strong; frame muscular; movements without grace; angularity of features and physique; stature is medium or tall; body has a firm pose; countenance is severe and serious; complexion ordinarily sallow or swarthy; the hair dark brown or black; eyes black or brown. *Mental characteristics:* strong susceptibility and constancy of feeling; quick perception and precise judgment; capacity for reasoning; firm decision and will power; great violence in anger; stubborness; great pride and ambition; usually generous and magnanimous.

Fig. 229



Man with characteristics of the bilious temperament in predominence.

Fig. 230

Individual with characteristics of the sanguine temperament in predominence

Fig. 231

Individual with characteristics of the nervous temperament in predominence.

Fig. 232

Individual with characteristics of the lymphatic temperament in predominence.

The Sanguine Temperament. (Fig. 230.)—*Physical characteristics:* the highest manifestation of physical life; active circulatory system; pulse excitable and irregular; stature above the medium; body well proportioned; movements graceful, regular and easy; athletic type; voluptuousness in females; vivacious and beautiful; complexion fresh and ruddy; red lips; hair light or auburn, rarely dark, sometimes red; eyes are light in color, usually blue. *Mental characteristics:* Great

hopefulness and elasticity of mind, optimism; enthusiastic, but have little perseverance; fondness for admiration or display; fickleness; great liberality of sentiment; little ability for self-denial; seldom undergo mental suffering.

Nervous Temperament. (Fig. 231.)—*Physical characteristics:* Quick movements; great sensitiveness; muscular system small; body refined and slender; angular; head proportionately large; the skin is soft and of fine texture; complexion generally light, sometimes sallow; hair is fine and dark; not plentiful; eyes gray or very dark. *Mental characteristics:* very highly organized; great fluctuation of feeling of exhaltation or depression; keen sympathy; great anxiety or fear; ability to endure physical suffering in excess of what would be expected; predominates in highly civilized countries.

The Lymphatic Temperament. (Fig. 232,)—*Physical characteristics:* tends to heaviness and roundness of the body; medium or low stature; cellular repletion due to lymph; slow circulation; pulse weak; large rounded head; features heavy and expressionless; hair light and coarse without lustre; complexion heavy and muddy; eyes dull gray and small. *Mental characteristics:* Little passion or ambition, great self satisfaction; contentment and good nature marked; judgment calm, and slow but sure; plodding and industrious; individuals successful in business; safe to trust.

The physical characteristics associated with the four basal temperaments are well described and may be easily studied in the comparative table on page 259 prepared by Dr. A. H. Thompson. It must be remembered that these are basal temperamental types which are more ideal than real, and that pure types seldom occur. Few individuals exist who possess all the characteristics of a single temperament.

The description applies therefore more largely to principles than to individuals, but the tables of binary temperamental compounds on pages 260 and 261 describe combinations of physical characteristics which may frequently be observed in individuals. Combinations of three basal types exist in many persons, and in addition there is a large class in whom the temperamental indication is so obscure as not to be discernible at all. In the diagnosis of the temperaments or the predominating temperamental indication in any individual, constant observation of people and keen perception are necessary and good judgement in selecting the characteristics which are most significant. No rule can be given which will completely cover the ground, but the proportion of individuals who do not possess characteristics which indicate the predominance of one temperament over the others, is small. In America because of the larger number of races which have contibuted to its population, the diagnosis of temperament is particularly difficult. The sanguine and bilious are the usual basal temperaments in this country although these are not so distinctive as is the nervous of the Latin races and the lymphatic of the German and Dutch races.

TABLE I.—*The Indications for Diagnosis of the Temperaments.*

	Basis.	Stature.	Osseous development.	Muscular development.	Contour.	Circulation.	Face and features.	Skin and complexion.	Hair.	Eyes.
(1) The lymphatic temperament.	The predominance of the lymphatic system.	Rather above medium, but sometimes below.	Coarse and loose; articulations voluminous, but badly formed; extremities large and ugly.	Soft and flabby, and act with difficulty and slowness.	Fulness of body, sometimes amounting to corpulence, and without grace or beauty.	Heart sluggish; pulse slow and feeble; blood thin, pale, and lymph-like.	Face full, heavy, and expressionless; cheeks pendant; lips thick, etc.	Skin a dull leaden white, faded or yellowish, and generally cold and moist.	Fine and silky, but lustreless; a pale blonde or sometimes reddish or flaxen.	Pale blue or gray; faded and expressionless.
(2) The sanguine temperament (the xanthro-vital of Dr. Jacque).	The predominance of the arterial circulatory system, and of the lungs and capillary vessels generally.	Generally above the medium, sometimes quite tall.	Well-proportioned; articulations light and slender; the extremities indicating grace and activity.	The muscles finely moulded for elegance and suppleness.	Slight and graceful, or full, but not heavy.	Heart vigorous, the arterial flow active and bounding; the blood red and rich.	The face inclined to roundness; the lips full and red; the features well marked and full of vivacity and expression.	The skin fine, soft, and transparent; the plexion fresh and ruddy.	The hair blond, red, or chestnut, rarely dark or black.	The eyes blue, brilliant, and expressive.
(3) The bilious temperament (the motive temperament of Dr. Jacque).	The predominating organ is the liver, which influences the whole system.	Medium or tall.	Angular and rugged; rough articulations and large extremities.	Strongly defined; cord-like and hard; the movements slow and deliberate.	Angular and rugged, massive and ungraceful.	The heart slow, the venous circulation predominating over the arterial.	Harsh and angular; severely expressive.	Skin coarse and dry; complexion olive, tawny, or dull.	Hair coarse, dark (often black), and abundant.	Eyes black or brown, small and piercing.
(4) The nervous or mental temperament.	The excessive development and morbid activity of the brain and nervous system.	Below the medium; slight and wiry.	Small frame; the bones light and thin; the skull very full over the large brain.	Small muscles; thin, strong, and nervously active, and given to spasmodic efforts.	Thin and habitually emaciated.	Heart nervously active; blood thin, pale, and innutritious.	Sharp and thin; expression nervously animated.	Fine and pale, sometimes sallow.	Fine, light, and soft.	Light gray or blue, restless, and often morbidly brilliant.

TABLE II.—*The Binary Temperamental Compounds.*

	Basis.	Stature.	Osseous development.	Muscular development.	Contours.	Circulation.	Face and features.	Skin and complexion.	Hair.	Eyes.
(1) Sanguo-bilious.	The combining of arterial and venous or biliary elements, with predominance of the first.	Above average size.	Strong and heavy; head square; jaws large.	Full and well-developed, but not graceful.	Disposed to irregularity; mostly sharp and angular.	Full in both arterial and venous systems; heart strong and active.	Rather angular; high cheek-bones; nose large; lips full and large.	Rather smooth; little color, or dark and yellowish.	Black or dark, coarse or curly; not usually abundant; beard full; eyebrows straight.	Full, and usually dark and lustrous.
(2) Bilio-sanguine.	Slight predominance of the bilious element, with sanguine modification.	Much above average, of tall stature.	Wide and strong, bones large; articulation full.	Knotty and hard; modified by sanguine roundness.	Broad shoulders; full chest; and strong, round limbs.	Strong and dark; heart quick and full.	Cheeks full; forehead large; jaws large and round; chin heavy; mouth large; lips full and red.	Skin smooth; soft and creamy, varying to rosy olive.	Dark, wavy, and luxuriant, and fine in texture; beard full; eyebrows arched.	Eyes dark, large, lustrous, and expressive; sometimes deep blue.
(3) Lymphatico-bilious.	Lymphatic and bilious elements, lymphatic predominating.	Decidedly above average size.	Rather coarse and irregular; articulations large.	Medium and well-developed.	Well-rounded and inclined to fulness in women.	Full, but not red or vigorous; heart irregular.	Face full; forehead large; jaws and chin round; mouth large; lips thin and bluish.	Rather rough and and dark-colored, with tendency to ephelides, moles, etc.	Hair and beard dark, full, and wavy; eyebrows straight and heavy.	Eyes dark-brown or gray.
(4) Bilio-lymphatic.	Bilious and lymphatic elements, bilious predominating.	Above average size.	Large and coarse, without strength or grace.	Irregular, or full, but weak.	Round and soft, inclined to flabbiness.	Weak and thin, or dark; heart irregular.	Cheek-bones large; forehead full; jaws large and square; mouth large; lips thin.	Dark, pallid, and opaque.	Dark, moist, straight; beard heavy and dark; eyebrows straight	Large, dark, or dark gray; weak and expressionless.
(5) Nervo-bilious.	Nervous and bilious elements, the former predominating.	Average or irregular stature.	Bones irregular, weak, and angular.	Wiry and cord-like; or may be rather full and strong.	Small, irregular, and shapeless.	Thin and dark blood; heart irregular and weak, or active and cord-like pulse.	High cheek-bones; forehead large; jaws small, and chin small and pointed.	Inclined to dark, and often sallow and pallid.	Dark; decidedly curly; beard sparse and irregular.	Dark-brown; rather expressive.

(6) Bilio-nervous.	Bilious and nervous elements, the former predominating.	Less than average size.	Small, weak, and irregular.	Small, weak, and poorly developed.	Slight and small, or large and coarse.	Dark and weak; heart active.	Cheek-bones high and prominent; lower face thin and contracted.	Dark and subject to freckles.	Ranges from dark-brown to dark red; beard dark to red; eyebrows arched.	Small; hazel to light, or dark brown to black.
(7) Nervo-sanguine.	Nervous and sanguine elements, the nervous predominating.	More than average size, as a rule.	Strong and shapely; articulations finely proportioned.	Full and well-shaped; strong and graceful in movement.	Well-moulded, fine limbs and broad shoulders.	Blood red and bounding; heart active.	Cheeks full; forehead round; jaws and chin well shaped.	Fair, clear, and pink-toned.	Hair and beard sandy to red, full and wavy; eyebrows light and arched.	Large: light hazel or clear blue
(8) Sanguo-nervous.	Sanguine and nervous elements, the sanguine predominating.	Rather less than average size.	Small and light; articulations small.	Small, but graceful and vigorous.	Rather slight, but sometimes full and rounded.	Blood full, but light-colored; heart active.	Forehead high and broad; cheek-bones prominent; lower face rather thin: chin small.	Fair and smooth, with tendency to ruddiness.	Light and curly, but fine, with tendency to baldness; beard scanty; eyebrows light and arched.	Blue or gray; full; large and expressive.
(9) Lymphatico-sanguine.	Lymphatic and sanguine elements, the first predominating.	More than average height.	Bones good and well-developed; articulations well-shaped.	Fairly well-developed, and rounded; rather soft and medium in activity.	Round and shapely; full and graceful, but disposed to obesity.	Good medium as to blood, color, and heart action.	Face round; cheeks full; jaws large; mouth shapely, and lips full and red.	Very smooth and fair, pinkish, inclined to florid; sometimes freckled.	Blond or light chestnut, inclined to curl; beard medium; eyebrows dark and arched.	Light gray or blue; large and full.
(10) Sanguino-lymphatic.	Sanguine and lymphatic, the sanguine predominating.	Above average in size; inclined to be tall.	Bones long and well-developed; articulations shapely.	Full, but not hard, active, but not enduring.	Inclined to irregular fullness, often corpulent.	Full, red, and active; heart strong.	Large and full; forehead high; jaws and chin round and full; lips full.	Soft and smooth; ivory-white to pink complexion.	Dark to light chestnut, sometimes luxuriant; beard full.	Large, light-colored; with placid expression.
(11) Lymphatico-nervous.	Lymphatic and nervous elements, the first predominating.	Stature very irregular, but usually above average.	Usually large, with coarseness; articulations full, but ill-shaped.	Rather full, but moderately strong and active.	Usually full and round, but irregular.	Blood thin and full; heart weak; pulse irregular.	Face round; forehead large; cheeks full; lips thick.	Dark to light; usually pallid, with little color.	Variable in color; slightly wavy; beard light.	Variable, light or dark, sometimes light hair with dark eyes, or *vice versa.*
(12) Nervo-lymphatic.	Nervous and lymphatic elements, the nervous predominating.	Average size or below.	Bones moderate in size; of low structure.	Low development, full but weak.	Round and soft, or thin and flabby.	Blood light and thin; heart weak and nervous.	Face thin, or full and heavy; forehead high and bulging; mouth weak; lips thin.	Light, pallid, coarse skin, inclined to blotches.	Light in color; slight in quantity; eyebrows straight	Dull, grayish; inclined to green or hazel in color.

TABLE III.—*The Temperamental Characteristics of the Teeth.*

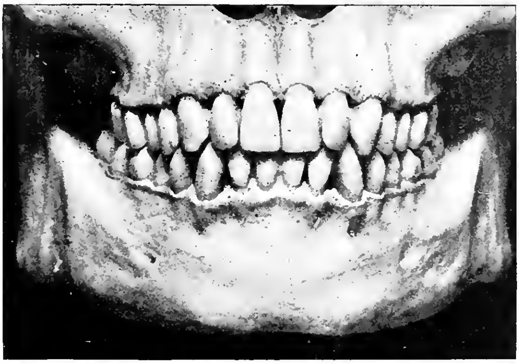
Basal temperaments.	Size.	Shape.	Color.	Texture.	Enamel.	Cusps and edges.	Arrangement.	Articulation.	Arch.	Vault.	Gums.	Rugæ.
(1) Bilious temperament.	Large and strong.	Conical; long, and angular.	Strong; bronze yellow.	Dense and hard.	Rough and strong; often transverse lines.	Square and heavy.	Close set and regular.	Firm, close, and well-locked; plane much curved.	Large, square, with prominent canines.	High and square.	Orange-red; dense; margins heavy.	Heavy, square, and rugged.
(2) Sanguine temperament.	Medium in size.	Well-proportioned; curved and rounded.	Cream-yellow; darker at neck.	Rather dense and strong.	Smooth, lustrous, and brilliant.	Rounded and well-shaped.	Rather close and regular.	Moderately firm and close; wears to square bite; plane curved.	Round; square; finely shaped.	Round and arched.	Red or pink; health-line clear; full-arched margins.	Numerous and graceful in outline; well-rounded.
(3) Nervous temperament.	Small or medium.	Long, conical, and rounded.	Pearl-blue or gray.	Average density or soft.	Smooth, polished, and translucent.	Long, thin, sharp, and transparent.	Irregular; disposed to lapping and malposition.	Long and penetrating, but irregular.	Round; V-shape; of "Gothic arch."	High and Gothic in shape.	Pale and thin margins; delicate and shapely.	Small and sparse.
(4) Lymphatic temperament.	Large and coarse.	Ill-shaped; broad and flat.	Pallid, opaque, muddy, or yellow.	Brittle and chalky.	Coarse, opaque, and dead finish.	Poorly defined; coarse and blunt.	Not close, but regular.	Loose, flat, and irregular; plane flat.	Large and round; "horseshoe" arch.	Low and flat.	Pale and soft; margins thick and undefined.	Sparse and flat.

The illustrations, Figs. 233, 234, 235, and 236, show characteristic dentures of the four basal temperaments.

Fig. 233

Denture whose characteristics are chiefly those of the bilious temperament. (Photograph of a specimen in the Wistar Institute of Antomy.)

Fig. 234



Denture whose characteristics are chiefly those of the nervous temperament. (Photograph of skull in collection of Dr. V. Walter Gilbert.)

Fig. 235

Denture whose characteristics are chiefly those of the sanguine temperament. (Photograph of a specimen in the Wistar Institute of Anatomy.)

TABLE IV.—*The Temperamental Characteristics of the Teeth.*

Binary compounds.	Size.	Shape.	Color.	Texture.	Enamel.	Cusps and edges.	Arrangement.	Articulation.	Arch.	Vault.	Gums.	Rugæ.
(1) Sanguo-bilious.	Large and very strong.	Large and full-formed; angles undefined.	Dark yellow.	Strong and of good quality.	Rather opaque and rough.	Strong, heavy, and well-defined.	Close set and disposed to malposition.	Close and well-locked; plane curved.	Round-square.	Round and high.	Deep-red; margins well defined.	Heavy, numerous, and angular.
(2) Bilio-sanguine.	Medium or large.	Full and square; rather angular.	Rich yellow cream-color.	Dense and good quality.	Rather smooth, but sometimes good.	Finely shaped and full.	Regular and close set.	Close and well-locked; plane curved.	Round-square, or square.	High and square arch.	Red or pink; margins sharp and well-defined.	Well-marked and numerous.
(3) Lymphatico-bilious.	Large and coarse.	Large and irregular in form.	Dark-yellow or muddy.	Mixture of flinty and chalky.	Rough, dull, and opaque.	Thick and short.	Loose, but regular.	Loose and flat; the plane level.	Round, or round-square.	Rather low, but arched.	Red and soft; margins ill-defined.	Sparse and shapeless.
(4) Bilio-lymphatic.	Usually large.	Square and heavy, angles sharp.	Yellowish, but clear.	Soft and brittle.	Rather smooth and disposed to cross lines.	Short, thick, and heavy.	More or less spaced, but regular.	Rather firm, but flat plane.	Rather square.	Arched and low.	Pale to red; margins well-marked.	Close set, but narrow.
(5) Nervo-bilious.	Variable—large to small.	Broad or long; sometimes "bell-crowned."	Yellowish and bluish in varying combinations.	Rather soft and frail.	Smooth and dull, or translucent.	Long or square.	Close, but disposed to torsion and malposition.	Long and deep, but not close; plane uneven.	Square or V-shaped; often abnormal.	High and square or contracted.	Pale and thin; margins ill-defined.	Thin and very tortuous.
(6) Bilio-nervous.	Medium large.	Long and often narrow.	Bluish to yellow.	Rather soft and weak.	Smooth but irregular surface.	Long and rather translucent.	Close, and disposed to malposition.	Deep and close; plane curved.	Square and narrow; often abnormal.	High and tends to Gothic form.	Red or pale; margins thick.	Large, deep, and well-curved.

(7) Nervo-sanguine.	Average in size.	Fine shape; rather long.	Rich cream-color to bluish.	Strong and excellent in quality.	Smooth, brilliant, and strong.	Well-marked and shapely.	Close and shapely, but strongly disposed to malposition.	Close, deep, and firm; the plane curved.	Round V; fine in outline.	Medium and well-arched.	Deep pink and clear; margin well-marked; festoons graceful.	Long and well-marked; numerous and graceful.
(8) Sanguino-nervous.	Average size.	Well shaped and moulded; narrow necks.	Bluish cream-color.	Good, but dentine sensitive.	Smooth, bright, and translucent.	Good and shapely.	Well set, but inclined to crowding.	Close and deep; plane irregular.	Round V; good shape.	High and well-arched.	Pink and clear; margins sharp.	Numerous and sharply defined.
(9) Lymphatico-sanguine.	More than average.	Large and round.	Grayish-cream.	Soft and poor in quality.	Smooth and clear.	Good shape; round and full.	Well arranged, roomy, and often spaced.	Close, but shallow, and flat plane.	Round or round-square.	Flat or round.	Transparent, pink; margins loose.	Low, flat, and sparse.
(10) Sanguo-lymphatic.	Large.	Broad and round; angles rounded.	Creamy-gray.	Fairly good and strong.	Smooth, but rather opaque.	Round, but well-defined.	Well-arranged, but disposed to spacing.	Flat, but regular.	Round or round-square.	Well-arched, but low.	Clear pink; margins full.	Numerous and well marked.
(11) Lymphatico-nervous.	Below average.	Well-shaped, but irregular.	Grayish-blue.	Soft and sensitive.	Smooth and clear, or dull and rough.	Usually sharp and well-shaped.	Rather irregular, and disposed to crowding.	Loose and irregular; plane flat.	Round or round V; much subject to abnormal forms.	High and narrow.	Pale and soft: margins thin.	Low and ill-shaped.
(12) Nervo-lymphatic.	Average size.	Good shape and length.	Bluish-gray.	Soft, weak, chalky, and sensitive.	Smooth, soft, and translucent.	Long and sharp, but weak.	Close, but uneven plane.	Long and deep, but irregular.	V-shape or abnormal.	High and irregular.	Soft and light-colored; margins ill-defined.	Soft and irregular; sometimes quite low.

FIG. 236

Denture whose characteristics are chiefly those of the lymphatic temperament. (Cryer.)

AGE.

From infancy to old age a gradual succession of changes in the bodily tissues occurs. In common with the other tissues of the body, the teeth are influenced by the increasing years. From the time of the establishment of the permanent denture until the time it is lost, these changes occur in regular progression, so that for the most part the physical characteristics of the teeth are constantly in accord with the physical characteristics of the individual at all times during his life. In some persons these alterations are more discernible than in others, but after the age of thirty-five or forty the marks of time may be found in almost every instance.

The chief alteration which may be attributed to the influence of age is a deepening of the color of the teeth. This is a molecular change in their tissues which is physiolgic in nature. It occurs most strikingly in individuals of the bilious and saguine temperaments, the yellow shades of whose teeth are markedly deepened. This change amounts to two or three shades as measured by the shade-guide for artificial teeth. It also occurs to a lesser degree in the teeth of the nervous and lymphatic temperaments. Due regard, therefore, should be taken of this fact in the selection of artificial teeth for individuals past forty, and a proportionally darker shade of the color suitable for each temperament should be selected to correspond with the age.

Beside the wear of the teeth, which is to be discussed later and which is a frequent accompaniment and an indirect result of old age, another influence of age must be mentioned. This is the physiologic recession of the gums about the crowns of the teeth which occurs as life goes on. It must not, of course, be confounded with recession of the gums due to pathological processes. In individuals past forty there is a recession of the gum tissue from about the necks of the teeth, exposing the cementum. The round full festoons of the gingivæ characteristic of youth disappear, and instead, the line between the gum and the teeth becomes accentuated. This is more strikingly evident in some tem-

peraments than in others. It occurs particularly in individuals of the lymphatic, sanguine and bilio-lymphatic temperaments. In the arrangement of the gums of artificial dentures due cognizance should be taken of this peculiarity.

THE USE OF THE TEETH.

The use of a denture through the course of a human life must necessarily leave some evidences of wear upon the teeth. Although the enamel covering the teeth is the hardest structure in the body, yet it is unable to resist the wear which occurs in the performance of the masticatory function. The character and the amount of wear of the teeth depends upon three factors: the food, the manner of movement of the jaw, and the character of the dental tissues themselves. According to J. H. Wassal[1] and A. H. Thompson[2] the teeth in the skulls of prehistoric man show evidences of great wear. They wore out in the performance of their daily duties, because of the rough character of the food. For the same reason skulls of American Indians display similar evidences of attrition, large quantities of finely divided sand having become mixed with their corn meal in its manufacture. Modern conditions of civilization are not so conducive to wear of the teeth. Individuals are frequently seen who have reached the age of thirty-five or forty years and yet exhibit little evidences of wear.

The amount of wear bears no relation to the age of the individual. It is more directly related to the temperament, or in other words, to the physical resistance of the teeth in certain temperaments. Wear occurs most commonly in those of the lymphatic temperament, and in the combinations of this temperament and the bilious with the sanguine.

Harrison Allen says, "the wear is not related to the form of the condyle of the jaw," but inasmuch as worn conditions of the teeth are most frequently found in cases characterized by lateral movement of the jaw, it is believed that they must be connected in some way.

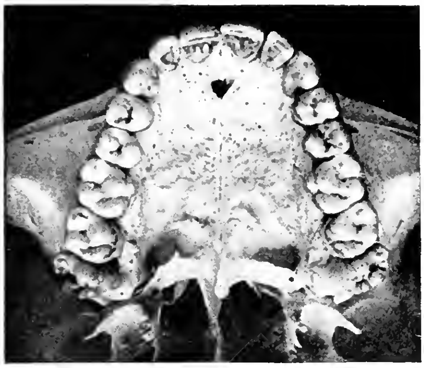
The existence of certain habits, as that of tobacco chewing, as pointed out by A. H. Thompson[3], is responsible for wear of the teeth, the silica mixed with the tobacco exerts an abrasive influence upon the teeth. According to I. B. Davenport[4], in a perfect denture wear proceeds evenly upon all its morsal surfaces. Thompson describes the process as follows: "The points of the tubercles of the molars and the cusps of the bicuspids and canines are first worn off, exposing the dentine, which wears out in little cups surrounded by a wall of enamel. The edges of the incisors are worn to show a fine line of dentine." In those temperaments in which the cusps are short, as the wear proceeds further, the lower jaw moves forward, so that the incisors are brought into the position of an edge-to-edge bite. Dentures with long penetrating cusps exhibit a different kind of wear from those in which the

[1] The Dental Cosmos, Vol. xliii., p., 977.
[2] The Dental Cosmos. Vol. xlii., p. 519.
[3] The Dental Cosmos, loc. cit.
[4] International Dental Journal.

cusps are short. The following degrees are noted by C. H. Ward[1]; 1st degree, enamel somewhat worn; 2d degree, cusps disappear and dentine exposed; 3d degree, teeth reduced in height; 4th degree, teeth worn off to the necks.

It is evident from the standpoint of dental prosthesis that the imitation of extreme degrees of wear is undesirable. It will seldom be

FIG. 237



Typical arch outline of bilious temperament. (Photograph of a specimen in the Wistar Institute of Anatomy.)

FIG. 238

Typical arch outline of nervous temperament. (Photograph of a specimen in the collection of Dr. M. H. Cryer.)

FIG. 239

Typical arch outline of sanguine temperament. (Photograph of a specimen in the collection of Dr. M. H. Cryer.)

FIG. 240

Typical arch outline of lymphatic temperament. (Photograph of a specimen in the Wistar Institute of Anatomy.)

found wise to imitate more than the first and second degrees, inasmuch as the third and fourth are seldom seen excepting among savage people. Of the first degree two types of wear are noted as worthy of imitation so far as the incisors are concerned. They are, first, that observed in cases in which there is a pronounced overbite. (Fig. 197.) In this in the forward and backward movement of the jaw,

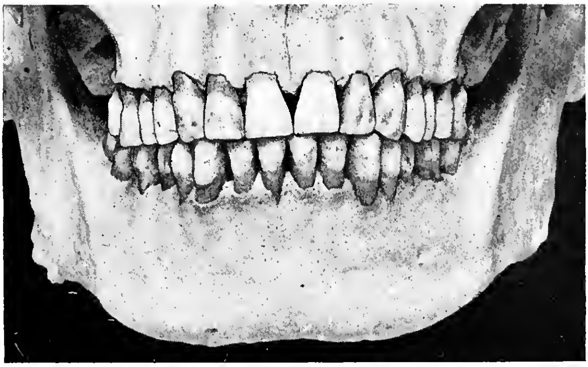
[1] The Dental Cosmos, Vol. xl. p. 261.

the occlusal ends of the upper and lower incisors are worn, the wear upon the upper occurring at the expense of the lingual surface, that upon the lower being at the expense of the labial. This results in a straightening of the line of occlusal edges of the incisors in both jaws.

Fig. 241

Denture exhibiting first degree of wear. (Photographed from living subject)

Fig, 242



Denture exhibiting second degree of wear. (Photograph of skull in collection of Department of Dentistry, University of Pennsylvania.)

Fig. 243

Denture exhibiting second degree of wear on the right, third degree on the left. (Photographs of skulls in collection of Department of Dentistry, University of Pennsylvania.)

the labial surfaces of the upper and the lingual of the lower ending in a sharp edge which is more or less continuous from side to side. (Fig. 241.) After a while some little chipping of the enamel edge of the upper may occur making this line irregular. The second type of wear in the incisor region is that in which the overbite is not so pro-

nounced, where the incisal edges of the lower teeth move more nearly directly across the edges of the upper. This results in the wearing of grooves at such places as the teeth come in contact. (Fig. 242.) This is not so extensive a degree of wear as occurs in the first type, and is more frequently observed.

The second degree of wear in the incisal region is common to those dentures in which an edge-to-edge bite exists. Here the enamel is extensively worn through and the dentine is exposed. (Fig. 243.) As the attrition proceeds the length of the crown is gradually reduced, the dentine is frequently stained and a characteristic appearance results. The margins of the enamel are chipped and an irregular incisal line is produced.

CHAPTER VI.

THE EXAMINATION, PREPARATION, AND STUDY OF THE MOUTH PRELIMINARY TO THE INSERTION OF ARTIFICIAL TEETH.

By A. DeWitt Gritman, D. D. S.

A careful preliminary examination of the mouth is a matter of vital importance to the successful insertion of substitutes for the natural teeth. Two objects are held in view in this examination: The first is to determine the state of health of the tissues of the mouth, particularly of those to be in relation with the artificial denture. As the latter is at best a foreign body, and does not tend to improve the general hygiene of the mouth cavity, it is important that the tissues with which it comes in contact shall be perfectly healthy and not the seat of pathological processes. It is also an evident necessity that the tissues which are to afford support to the denture, whether it be plate or bridge, must be sound and strong. In this connection must also be considered the means of bringing these tissues to a state of health and usefulness in cases where the latter condition does not exist.

The second object has to do with plans for the prospective denture. At this examination it will be necessary to determine the type of denture which is to be employed, the general plan of its construction, its means of retention, and whether the mouth is favorable thereto, together with any means necessary to prepare the mouth for the reception of the denture. In view of these facts, it is evident that thoroughness in this preliminary examination is desirable.

The condition of the soft tissues of the mouth may be ascertained by visual examination, either directly or by means of a mouth mirror and by palpation with the finger.

Familiarity with the general appearance of healthy mucous membrane, its color and consistence, and ability to recognize aberrations from this should be part of the equipment of the examiner. If the mucous membrane, which in the normal state is a firm resistant structure capable of giving adequate support to the denture, is not in a state of health, it is evident that it must be brought to this condition before the impression is taken. This will presently be discussed.

If the mouth is edentulous, and inspection shows its tissues to be healthy, further examination and study have only to do with the plans for the denture. A careful digital exploration of the entire surface to be covered by the future plate should be made to determine the location of hard or soft areas, as account must be taken of these in providing for the retention of the plate. Special attention must be paid to the retention of the plate in the lower jaw, and as this will mainly depend on the action of the muscles attached to the mandible, the location

of the margins of the future plate must be carefully noted, as well as the positions of the labial and lingual fræna. These should be accurately marked upon the cast, for if these be neglected in all probability the lower plate will not rest undisturbed upon the jaw.

If there are teeth in the mouth the examination must determine if they are strong and healthy, and if not, whether they may be made so. A judgment of their probable tenure of life and usefulness must also be formed in this preliminary survey. The presence of teeth and their location must be accurately mapped and recorded, and if these be scattered in the front of the mouth their color and position must be carefully noted.

MORBID CONDITIONS OF THE GUMS.

The condition of the gums in the mouths of many patients presenting themselves for prosthetic work is not always favorable to the immediate insertion of artificial dentures. It is inadvisable to place an artificial denture in a mouth until all the tissues, especially those in direct relation with the plate, are in a healthy condition.

A general hyperæmia of the mucous membrane is frequently present, produced by the presence of roots or fragments thereof, or of more or less diseased teeth. This is frequently aggravated by a general lack of hygienic care on the part of the individual because of a hypersensitive condition of the mucous membrane and tenderness of the remaining teeth. The removal of the useless roots and teeth, and the use of an astringent antiseptic mouth-wash, is usually all that is necessary to render the mouth in suitable condition to receive the denture.

Long-continued sickness is frequently responsible for gingival inflammation, which is increased generally by lack of proper care of the oral cavity during the period of illness and even during convalescence. It may be remarked that proper care of the oral cavity during illness is not yet one of the solved problems in nursing.

Stomatitis is not infrequently observed. As its name indicates in a general way, it is inflammation of the mouth, but this term embraces a large number of subdiseases, such as aphthous stomatitis, ulcerative stomatitis, mercurial stomatitis, syphilitic inflammations, etc., divisions too numerous for the average prosthetic worker to treat satisfactorily, and they had best be referred to a specialist for proper treatment. Stomatitis simplex, or ordinary inflammation of the mucous membrane, is so common that it should come under his special care. If this exists, there must be careful lavage of the mouth three or four times a day with an antiseptic solution. Potassium chlorate, 15 grains to the ounce of water, is an effective mouth-wash. A 2 per cent. solution of hydronaphthol in alcohol is another excellent mouth-wash for all forms of gingival inflammation. If this condition is the result of gastric disturbance, much help may be gained by the use of the following for internal administration:

℞. Acidi hydrochlorici dil. . . . . f℥ij.
Sig.—Five drops well diluted with water after meals.

Much of the gingivitis found contiguous to remaining sound teeth is due to calculi at the free margin of the gums. This may result in extensive inflammation of the peridental membrane and finally in pyorrhea alveolaris. A discussion of the treatment of the latter properly belongs elsewhere. Suffice it to say that all teeth must be thoroughly scaled, and the patient advised to use the following mouth-wash:

℞.	Zinci chloridi	5–10 gr.;
	Aquæ menth. pip.	℥ij.—M.

Sig.—Use as a mouth-wash for a week.

Another formula will be found excellent:

℞.	Hydronaphthol	gr. xx;
	Alcoholis	℥j;
	Aquæ	℥j.—M.

Sig.—Twenty drops to a small tumbler of water, as a mouth-wash, to be used once daily.

Unless teeth so affected are placed in a healthy condition, it is useless to attempt to insert a plate while they remain as centers of disease.

It is unnecessary to enlarge further in this direction, as it would carry this chapter too far afield to attempt to cover all the pathological conditions interfering with the insertion of artificial dentures. Suffice it to say that all pathological lesions of the tissues of the mouth of whatever nature must be treated and the entire mouth restored to normal health before anything is done in the way of substituting artificial for the natural teeth.

RETENTION OR EXTRACTION OF NATURAL TEETH.

It would be difficult to overestimate the value of a thorough preliminary examination of the mouth for which an artificial denture is required, if it only served to settle the various questions arising in relation with any natural teeth and roots which remain in place. These teeth and roots must be considered carefully in the light of the future comfort of the patient, as well as in their bearing upon the work of the operator. There is probably no greater problem in prosthetics than that presented in such cases, nor one requiring the exercise of more judgment. In some mouths there will be presented sound roots and those in all stages of decay, teeth with vital pulps and those with pulps no longer living. If the roots are healthy, are they suitable for crowning, and will crowning be of advantage to the patient? Will the roots if properly treated and crowned be of service in mastication, or will the artificial crowns themselves eventually produce pathological conditions ending in destruction of the roots? Are the vital teeth present of prospective value sufficient to force their retention in the mouth? Will the vital teeth aid in the retention of the plate or prove an unending annoyance to the patient? These are queries which must be carefully considered and answered in all preliminary examinations.

It is clearly good practice to first extract all the teeth and portions of teeth that cannot be restored to health. Whether teeth and roots which are healthy or may be made healthy are to be retained or not must

be decided by two considerations, viz.: whether they will assist in the retention of the denture or whether they will interfere with its adjustment.

While the retention of artificial dentures is not the subject of this chapter, it assumes preliminary importance here in considering the extraction of roots and vital teeth. The retention of a plate is a matter of so great importance that the operator who fails to take this into consideration invites defeat. It is well understood that a full upper denture is more satisfactory in the ease with which it is maintained in place than a partial plate. The adhesion is, as a rule, adequate in the former, but in the latter it is subject to many disturbing elements. Very dry mouths interfere with retention, but this is not a common condition and does not need extended notice. Where it does exist, it is not an insuperable obstacle. Mouths in which the alveolus has been entirely resorbed, as is frequently the case in both jaws, present more serious problems, especially in the case of the lower jaw. Properly constructed plates can, however, be made of rubber for such cases that will exhibit remarkable adhesion. While these are frequently made heavy to overcome displacement, this is not absolutely required, provided care is taken to adapt them by wide flanges to meet the loose tissues subjacent to the alveolar ridge.

Greater liberty should be allowed in extraction in a mouth favorable to plate retention, while great conservatism should be observed in cases in which stable retention of the plate is doubtful.

Vital teeth may be of value as supports either in bridge-work or in plates, but in some instances they interfere with the stability of the artificial substitute. It will probably be wise to retain these as long as possible, but too much should not be expected in the way of their retention. The idea prevails, not only with patients but with some dentists, that artificial dentures cannot be used with the same satisfaction in crushing articles of food as natural teeth. Greater force can be applied with the latter it is true, but the extremity of force is not needed in mastication, and all food, of whatever kind, can be comminuted satisfactorily with a properly arranged set of artificial teeth.

The permanency of all isolated teeth and roots is, and must always be, a question of doubt. With adjoining teeth lost and resorption of the alveolus taking place continually, the tissues surrounding the isolated tooth must eventually give way, the pericementum becomes detached, and the result is eventually the loss of the tooth. This applies to all teeth and is one great obstacle to the permanency of bridge-work. There are cases, however, when an isolated molar is of great service to the operator, for a well-advised clasp upon it may stay the plate and add materially to the patient's comfort.

It is difficult, therefore, to give any opinion except in general terms as to the advisability of the extraction or retention of individual vital teeth. Each one must be judged by existing conditions. If canine teeth can be retained, they have a distinct value in giving form to the jaw which is not easily obtained by artificial substitutes. Even the

canine roots may be better treated and crowned than extracted. It is time wasted to attempt to save a single anterior tooth. Any isolated incisor is useless for appearance or for mastication, and it is extremely difficult to align artificial teeth with it satisfactorily.

Roots crowned, except in rare instances, are of doubtful value beyond temporary expedients. They may have a life of a few years, but eventually they are brought to the forceps. This is due to positive pathological conditions engendered by undue strain on the peridental membrane, or by direct irritation through the bands of the crowns and sometimes from imperfect root treatment.

There are not infrequently cases, however, where roots should be retained, especially in the anterior portion of the mouth. With care in their preparation for crowning these may be made of great value as a support to the artificial plate in mastication. Judgment is, however, necessary here, for the root or roots must be of the best quality and capable of being placed in perfect hygienic condition; otherwise their retention would be a mistake and result unhappily.

Whatever may be decided upon in this preliminary stage must be thoroughly done. If extraction is chosen, this leaves a socket of temporary bone tissue with sharp and friable edges, which becomes inflamed and may become infected if pains are not taken to prevent it. All the gums should be carefully bathed with an antiseptic wash, the sockets of extracted teeth painted with tincture of iodine or a 1 per cent. solution of formaldehyde. This latter should be carefully prepared to insure its being strictly 1 per cent., for beyond this strength it is very irritating. In case of excessive bleeding tannic acid may be effectively used, either in powder or in solution, the latter being preferred. Some operators recommend cutting away the exposed portions of the alveolus, but as this is a painful operation and is not absolutely necessary, it is usually better to leave the resorption to nature. A mild antiseptic wash should be used by the patient three times a day until healing of the tissues has occurred.

Length of Time to Supervene After Extraction.—The length of time it is necessary to wait before a so-called permanent denture can be prepared is a matter that can only be discussed in general terms. If the insertion of the denture is deferred until the last spicula of alveolar process is disposed of by resorption, it may be years before the final settling of the artificial denture upon the bone of the jaw or jaws is attained. It is not only necessary to wait for this final resorption, but it is not advisable to wait at all, for the process of resorption proceeds more satisfactorily if a temporary plate or plates be inserted.

It will be necessary to wait if possible a week after the extraction of useless teeth has been completed to permit partial healing of the irritated tissues. The exact time must depend upon the judgment of the operator. There are cases where shock supervenes after extraction, and it is not unusual to be obliged to defer all operations for a series of weeks. As a general rule a temporary denture may be prepared in the time first named.

The question of a temporary plate having been settled between the dentist and the patient, further procedure must be left to the judgment of the operator. A temporary denture is not supposed to be of much value in mastication, the sharp edges of the alveolar processes forbidding this. This condition frequently suggests the surgical operation of removing these projecting points with bone-cutting forceps. It is not uncommon, however, for temporary sets to be so satisfactory to the wearer that they are continued in use for years. They are not supposed to be in use for more than one year, when a more comfortable plate can be inserted; but even this must assume a semi-temporary character, for this resorption of the process is continuous until all the alveolus is removed, and this covers an uncertain period.

The method of taking an impression for these temporary dentures does not differ from that ordinarily employed, but while some use other materials in general prosthetic practice for this purpose, plaster alone should be used here, and for the excellent reason that the tissues surrounding the extracted teeth are left in a soft, flabby condition which any impression material requiring force will displace. Aside from this, it is well to have the sockets of the extracted teeth produced on the cast when the artificial teeth are ground to fit the gum.

It is sometimes demanded by patients that the natural teeth all remain in place until the temporary set is completed. When this is the case it will be necessary to take an impression of the mouth before the teeth are extracted, when the plaster teeth are cut off the cast, and their sockets carved out to represent resorption. This is frequently resorted to, but cannot be recommended for all cases, although it may be used to advantage, for example, in a case for which a partial plate is to be inserted after the removal of the six anterior teeth.

An impression in plaster should first be secured. This will give the operator the exact form and position of the natural teeth and enable him to reproduce them with greater satisfaction to the patient, who is always naturally sensitive to any marked change of appearance. After the length, size, and position of the natural teeth have been carefully noted, they may be cut from the plaster reproduction, and then the cast carved to represent the possible resorption certain to follow after extraction. A better way, however, is to take another impression after extraction and to use this to prepare the base for the temporary set. Plain teeth will be required here, and these must be arranged in anticipation of the great amount of resorption sure to follow. Such a plate belongs entirely in the category of temporary dentures and should be replaced inside the year. All temporary plates of the kind described have a value besides inviting by pressure more rapid resorption of the alveolar process, and that is their binding effort upon the tissues, retaining them in position and protecting them from the continued irritation which would otherwise occur in mastication.

It is possible that in rare instances surgical interference may be necessary in removing adhesions of cicatricial tissue, but these are not likely to occur where temporary sets are inserted soon after extraction,

and even should such take place, it has been the experience of the writer that the plate soon finds its proper bed, removing at the same time all trouble from adhesions. Patients are very sensitive to the thought of a surgical operation, and this should be adopted only as the last resort.

SURGICAL COMPLICATIONS.

The complications that may precede or follow the preparation of the mouth for an artificial denture, while briefly alluded to on previous pages, demand a more detailed discussion. After the removal of teeth, whether firmly implanted or where inflammatory conditions have produced a loosening of their attachment, there is more or less swelling of the gum which interferes with the correctness of any impression taken immediately. This necessitates delay to permit these abnormal conditions to subside before attempting the insertion of an artificial substitute.

Inflammation.—Where many teeth are to be removed, the possibility of subsequent inflammation is increased in direct proportion to the number of teeth involved. It is important that the tissues surrounding the teeth should be carefully protected from injury. The careless handling of the forceps may not only produce unnecessary suffering to the patient, but may be the cause of subsequent complications in the preparation of the denture. After the extracting has been done, care should be taken to discover if any portion of the alveolus is fractured and all loose pieces should be carefully removed. Pendant portions of the gum, the result of previous inflammatory conditions, or brought about by the operation, should be removed, as their presence delays the healing process. The removal of portions of the alveolus by a subsequent operation has previously been alluded to, and while not imperative, may sometimes be resorted to with advantage to both patient and operator. Before attempting this, however, the consent of the patient should be obtained, for while not a serious operation, it involves some pain and subsequent soreness. For this reason many prosthetic practitioners prefer to await the slower process of resorption. If, however, a surgical operation seems necessary, it must be performed under a local anæsthetic such as cocaine, or under nitrous oxide and oxygen, and be followed by the use of an antiseptic mouth-wash. Whether the surgical procedure be adopted or the slower process of resorption be allowed to take place, this antiseptic washing of the mouth should be continued by the patient during the period of healing.

Temporary Denture.—Should it be necessary to insert a temporary denture immediately after the teeth are removed, and this not infrequently happens, it will be necessary to follow a somewhat different procedure from that described on a preceding page. To prepare such a denture immediately after extraction involves many difficulties. Any attempt to secure an impression from which a plate at all permanent in character can be made must necessarily be futile, as the inflamed condition of the gums renders this impossible. A plate made at this

time will, therefore, as a rule, be of a strictly temporary nature, and this should be distinctly understood by the patient.

To secure a correct impression, plaster alone should be used. While opinions may differ as to the use of this agent under other conditions, there can be but one opinion as to its use for these cases, for it will, if properly prepared, cause little or no displacement of the parts, and reproduce them with an exactness not possible with any other material. It is very important that protruding portions of the gums should not be disturbed, and those remaining in place, in cases in which it has not been deemed wise to remove them surgically, should be reproduced on the cast upon which the plate is to be made.

The insertion of the temporary denture is not ordinarily productive of discomfort to the patient. The close adaptation of the base to the gum tissue serves as a binding bandage and will, by its continuous pressure, hasten the healing of the irritated areas. The time such a denture may be worn will vary and cannot be predetermined with accuracy; but when properly prepared, may serve for a long time with comfort to the wearer, and even in some rare instances take the place of a permanent plate. It is not, however, advisable to continue its use for more than a year, as complications may result which will interfere with the more perfect adaptation of the permanent denture.

Adhesions.—There is occasionally found a cicatricial adhesion between the mucous membrane of the cheek and that of the alveolar wall. This may be a cord-like attachment which marks the site of the fistulous opening of a previous alveolar abscess. The adhesion may be the result of extraction, the loosened tissue falling into the wound and becoming attached as a result. This may not be so situated as to call for surgical interference, but if it does interfere with the proper setting of the plate and endangers its stability, it should be removed. Wounds of the mouth, whether incised or from the use of caustics, may in healing cause extensive attachments between the cheek and alveolus, rendering the wearing of a plate difficult or impossible. This condition must also be treated before a denture is inserted.

The surgical principal involved in the procedure is to produce a separation of the parts and to continue this separation by the insertion of a plate which will prevent contact of the parts and consequently a reunion of the tissues. This operation may require local anesthesia for its performance unless it be of minor character; the use of a 4 per cent. solution of cocaine will be found satisfactory for the purpose. The incised parts should be washed with an antiseptic solution. The surface may be painted with styptic collodion.

If the adhesions are extensive, it will be found preferable to first take an impression of the mouth and prepare a cast for study. The cast is then cut away as is proposed by the surgical operation, and a plate without teeth prepared from it. The plate should be inserted in the mouth immediately after the operation to prevent the readhesion of the parts. A styptic should be applied after the operation; a spray of hydrogen peroxide usually checks hemorrhage. If this does not suffice, a solution

of tannin will usually be found effective. The cut surfaces may be dried with pieces of lint and painted with styptic collodion; as soon as this is dry the plate should be inserted. The patient must be directed to wash the mouth several times a day with an antiseptic, such as veruas, listerine, or 1 per cent. solution of hydronaphthol. The irritating character of the latter must be carefully noted and its use discontinued if the irritation is marked. This plate is simply placed in position to promote healing and prevent adhesion of the cut parts, and it should not be required to be in place more than two weeks. Should the granulated surfaces show an unhealthy appearance, they should be painted with a solution of nitrate of silver, 4 grains to the ounce. Tincture of iodine may also be found effective painted upon the gums.

CHOICE OF BASE.

The importance of the selection of a proper base for the artificial denture cannot be overestimated. Each case under consideration calls for careful study, and each presents a problem not easy of solution. Vulcanite, celluloid, gold, silver, platinum, aluminum, certain alloys of tin, known as "fusible alloys," and porcelain have all been used as a base for the denture. A consideration of the merits of each of these materials will now be in order. Vulcanite is the material in most common use for full sets, and, while not a perfect material, justly deserves a prominent position in the list if care is taken to overcome its disadvantages.

Under the early conditions of its use a serious objection to vulcanized rubber developed. In some cases it was liable to produce inflammation of the mucous membrane, or what was known as "rubber sore mouth." This pathological condition, manifesting itself shortly after vulcanite was introduced as a base for artificial teeth, became a problem to dentists and a source of much complaint on the part of the medical profession. So serious did this objection become that it threatened to destroy the usefulness of this material in dentistry. The question was taken up by the Pennsylvania Association of Dental Surgeons in the early sixties, and it was given over to Professors Wildman, Buckingham, and Truman to find, if possible, any ground for the charge that the inflammation was the result of mercuric action arising from some chemical change in the vermilion used in coloring the rubber. This research committee in its final report proved conclusively that mercury had nothing to do with the pathological condition in question. In their opinion it was due in part to the non-conductivity of the rubber, and possibly, in addition, to the rough surface left after vulcanization, which retained food particles in close proximity to the mucous membrane, exciting by their presence inflammatory processes. This latter conclusion was consequently confirmed by Black, who demonstrated that this condition invited microbic development, and the presence of toxic matter derived from this source produced the result complained of so universally. It had been demonstrated that metal as a base could be tolerated by the

membrane without producing undue irritation, and this was explained by its superior thermal conductivity and the fact that its polished surface prevented accretions.

This was so positively manifest in the use of metal plates that prosthetic workers adopted the use of tin foil placed over the cast before vulcanization. This became imbedded in the rubber and upon removal left the surface highly polished, requiring only the revolving brush to complete it. This was found largely to overcome the trouble heretofore experienced, and vulcanite as a base has become almost universal for ordinary sets. Its superior quality of lightness, comparative ease of manipulation, and adaptability to all conditions of the mouth, and, above all, its hygienic possibilities brought it into general use.

The introduction of rubber as a base for artificial teeth resulted in a revolution in prosthesis. The old methods of soldering were practically abandoned, with the result, natural to such sudden changes, of much inferior work. The merits and demerits of the material were not understood, nor were the proper methods to be observed in its use fully known. The material is still much abused at the present time.

The committee of the Pennsylvania Association, previously alluded to, demonstrated by careful research, microscopical and chemical, that rubber if properly vulcanized would not absorb the fluids of the mouth. Whether absorption would take place under a greater pressure than is present in the vulcanizer remains yet to be proved; but no plate examined gave any evidence of moisture, nor was imbibition possible under ordinary mouth conditions, the vulcanite being absolutely impervious. This applies, however, only to properly vulcanized rubber. There is doubtless much vulcanite inserted in mouths so porous as to become positively foul from the absorbed fluids and the decomposition of organic matter, resembling in this respect the early walrus carved specimens which are interesting now only as exhibits in dental museums.

Aside from its value for entire sets, it is even more important in attaching teeth to gold or platinum plates, completely relegating the older processes of backing and soldering to ancient history, and adding thereby not only to the comfort but to the health of the wearers.

While the non-conductivity of vulcanite is the main objection to its use for entire plates, this does not apply to rubber attachments on metal.

The gold base is still extensively used for a superior class of work. For full dentures it is usually employed as the base-plate proper with the teeth attached by means of vulcanite. This type of denture ranks next to that of continuous-gum in its hygienic qualities, its æsthetic possibilities, and its general acceptability to the mucous membrane. Its ability to transmit thermal changes, its highly polished and hence easily cleaned surface, and its freedom from interstices in which foreign matter might find lodgment, account for its general hygienic value. The relative thinness of the base-plates and its strength, its unalterable character in the mouth, and the possibility of any desired arrangement of the teeth in the vulcanite attachment are all advantages associated with this type of denture.

Because of the relatively high cost of the material it is not customary to insert full gold dentures until at least a year after the last teeth have been extracted, to allow the greater portion of the resorption to occur.

Gold offers many advantages for partial plates and is to be preferred in most instances. Where much strength is required, as, for example, when some of the teeth to be replaced are isolated, it is impossible to secure the desired strength in vulcanite.

Silver was the ordinary base for temporary dentures in former years by reason of its cheapness; it was also used for permanent plates for the same reason. Where cheapness in a full metal plate is now desired, swaged aluminum has come into general use for this purpose.

With the development of exact methods of casting, cast aluminum base-plates have also become a useful addition to our list of cheaper metal base-plates. Opinion is divided as to whether they are as satisfactory as the swaged plate, but it is likely that if careful attention is given to the technic of making, they will be equally useful.

For the lower jaw, as before stated, weight in the denture may be necessary. Base-plates cast of any of the fusible alloys recommended for this purpose will usually prove quite satisfactory.

Where something better than the metals ordinarily used is desired, the porcelain continuous-gum denture may be employed with great satisfaction, combining as it does artistic beauty, cleanliness, and weight.

The high æsthetic quality of the continuous-gum denture, its freedom from crevices in which foreign matter may be retained, and its highly polished surface, unalterable in the mouth, recommend it strongly in suitable cases.

Celluloid has practically become obsolete as a material for dental plates because of inherent defects in the material.

CHAPTER VII.

IMPRESSIONS OF THE MOUTH.

By A. DeWitt Gritman, D. D. S.

The first step incident to the construction of a successful denture, and one that does not always receive proper consideration, is to obtain a perfect plaster reproduction of the jaw for which the denture is intended, and this requires that an accurate impression of the same be taken.

The impression of the edentulous mouth, or of one requiring a partial substitute, has been defined variously at the several stages in the development of prosthetic dentistry. In the earlier periods it was regarded as quite sufficient to have a counterpart of the mouth made with softened wax (beeswax), and the impression was ordinarily taken without much regard to the conditions relating to the retention of the plate.

The present aim in all impression taking is the ultimate perfect adaptation of the plate, and in order to accomplish this a thorough study of the mouth is a prerequisite; without this adaptation a comfortable denture is not to be expected. Each mouth requires separate study, and no absolute rule can be laid down which will be of general value. The condition of the soft tissues, the various abnormal growths, the possibility of retention, especially in the lower jaw, the difficulty of overcoming in some persons the nausea consequent upon a foreign body being placed in the mouth—all these details must be considered; in fact, no impression should be attempted before every unfavorable condition has been studied and provision made to overcome it.

An impression of the mouth, in the modern acceptation of the term, means the first step in the successful retention of the denture, and in order that this may be accomplished there should be a careful study of the appliances and materials used for this purpose.

Impression Materials.—In order that the impression shall be an exact counterpart of the jaw, a suitable material to effect it is demanded. To answer the requirements of such usage, the material must readily become plastic and pliable at a temperature not injurious to the tissues of the oral cavity. It must copy accurately the irregular surfaces of the jaw, and with equal accuracy retain its form after the impression has been removed from the mouth. It must also harden in less than five minutes. It should neither contract nor expand. The perfect impression material has never been produced, and prosthetic operators are compelled to make use of present materials—viz., plaster of Paris, modelling compound, beeswax, and gutta-percha. These substances group themselves into two classes of materials commonly used for this purpose: one made into a plastic mass with water, and the other through

the action of heat. The first, plaster (plaster of Paris), is generally considered to have the greatest number of qualities recommending it to use. In proportion to the difficulty connected with the impression will plaster be found the best material to use.

IMPRESSION MATERIALS.

Wax.—This is a solid of animal and vegetable origin. Of wax from the animal sources there are beeswax, Chinese insect wax, and spermaceti. The vegetable waxes are Japanese wax, myrtle-berry wax, palm wax, etc.

Beeswax is secreted by all honey bees, and by them formed into the cell-walls of their honeycomb. It is this that was formerly the only material suitable for impressions, and the older practitioners of dentistry were forced, in the absence of better material, to prepare this from the mass furnished through the general markets. It is now prepared by the supply houses in convenient cakes ready for manipulation.

Beeswax is softened either by dry heat or in hot water, and is then kneaded into a doughy mass and applied as an impression material in proper trays. It is not a satisfactory material for this purpose, as it does not make a sharp impression, leaving a degree of uncertainty as to the final result. This fact has, therefore, placed it among the obsolete impression materials, but it has not been entirely driven from the prosthetic laboratory, where it still fills a proper place in many of the minor operations arising in practice. While springs were used in full dentures, wax served imperfectly to give a reproduction of the jaw. Since springs have become obsolete, and dependence on adhesion is the main reliance, beeswax has been abandoned as an impression material except in rare instances. Various combinations have been prepared to take its place as a heat-softened material. The most prominent of these is what is termed

Modelling Compound.—This is a material prepared to take the place of beeswax, as described. It is composed of a resinous gum, such as copal, dammar, or kauri, with stearin, French chalk, colored and flavored.

A formula of Mr. E. Lloyd Williams, of London, England, is as follows: "French chalk, one and three-quarter parts; kauri, one part; stearin, one and a half parts. Melt the stearin in an enameled pan and stir in the gum. When these are thoroughly incorporated, stir in the chalk. It may be colored with carmine and flavored as desired."

The Use of Modelling Compound.—A proper tray having been selected, a sufficient quantity of the modelling compound is taken and softened by dry heat and then placed in the tray, previously warmed. The surface of the compound is then slightly softened by passing it over the flame before it is inserted in the mouth. It is then placed in the position desired and pressed well into place, care being taken that all parts of the compound on the lateral margins are pressed by the index-finger into all the irregularities of the jaw. This completed, the compound

is left in the mouth to harden. This process may be hastened by the use of cold water ejected from a syringe or by the contact of an aseptic napkin saturated with water. When hard it is removed in the usual way, by slight pressure downward if in the upper jaw, and upward if in the lower. The removal is effected with far less difficulty than with plaster.

Advantages Claimed for the Compound.—It is claimed that this modelling compound takes a sharp impression, that is not subject to fracture on removal and that it compresses the soft tissues. These are true, but it must be remembered that a sharp impression does not always mean a perfect impression.

Disadvantages.—The force required to insert the compound necessarily disturbs the relation of the soft tissues with the jaw, and as these are moved from what may be termed the normal position a more or less imperfect impression of the mouth is obtained. The operator should aim to secure a perfect duplication of the tissues *in situ,* and this is always a question of uncertainty when a material like modelling compound is used. It is true that in skilled hands this material may succeed in giving apparently excellent results, but the general principles governing all operations of this kind must be carefully adhered to if the best results are to be attained.

The following quotation gives the method in use adopted by the Green Brothers, and, as this seems to meet fully the requirements of the material, it is given, in part, as quoted by George Henry Wilson, D. D. S., in his "Manual of Dental Prosthetics":

"The best position in which the operator may stand while taking this form of impression is directly back of the patient. The partially taken impression is removed from the mouth, thoroughly chilled, and any excess removed. The peripheral labial and buccal borders are warmed over a small weak Bunsen flame and quickly returned to place in the mouth. It is securely held in place with one hand, and while the patient is muscle trimming, the operator makes interrupted compression over the lips and cheeks with the disengaged hand. It may be necessary to rewarm and muscle trim several times, or an addition of soft dry compound may be needed upon portions of the rim of the impression. This addition may be made by "tracing on" with a stick of compound. When the operator is satisfied that the rim of the impression is perfectly adapted backward to the anterior border of the molar processes, the impression is thoroughly chilled, dried, and a small roll of soft modelling compound placed along the palatal border, upon the maxillary surface, and extended around the tuberosities to the malar processes. This addition is made quite soft in the small Bunsen flame, carried into the mouth, and quickly forced into place, removed, and dried. If it has not been sufficiently compressed, it is again softened and pressed in the mouth. The impression may now be considered complete. It is placed in cold water until thoroughly cold and, without drying, it is replaced in the mouth and very firm pressure made upon the lingual surface of the tray while the lip and cheeks are lifted

and drawn into position over the rim of the impression. The fingers are removed from the mouth and the patient requested to remove the impression."

The various uses to which modelling compound may be applied will be described under the proper headings.

Gutta-percha (Isonandra Gutta).—This name is applied to the concreted or inspissated juice of various plants. The geographical distribution of the trees producing this is very restricted. The yield of a well-grown tree is from two to three pounds of gutta-percha. Its use in the arts is very important, but is much restricted in dentistry, although many attempts have been made to use it as an impression material. It makes a sharp impression, and on account of this has been much used in the taking of molds for electrotypes, etc.

Its intractable nature has relegated it to other purposes than that of impressions in prosthetic work. Plaster of Paris and modelling compound have entirely superseded this as they have other materials.

The base-plate gutta-percha is furnished by the supply houses. It is not the pure gum, but other ingredients are mixed with it to give it a firmer body. This is used principally for temporary trial plates in the mouth.

Impression Plaster.—Plaster of Paris has already been considered as to its general qualities, but for use in this connection it must now be given more detailed attention. This is a special grade of plaster, very finely ground, and setting quickly. Properly mixed, it should set in about three minutes, but is not nearly so strong as casting plaster, which is used for the cast and flasking. When employed for impression taking it should be colored and flavored. The advantage of flavoring it is that this gives greater comfort to the patient, overcoming the disagreeable taste of plaster and reducing the tendency to nausea, which frequently interferes with absolute accuracy in the impression.

Coloring of Plaster.—By coloring the plaster the operator is enabled to remove it more readily from the cast, thus reducing the danger of mutilating the latter. The work can also be completed more quickly, and time is an important factor in all dental operations.

The preparation of this coloring fluid, as used by the writer, is as follows: To one ounce of carmine add five ounces of ammonia, and, when thoroughly dissolved, remove the cork and allow the fumes of ammonia to pass off. To one ounce of this solution add one ounce of Roger and Gallet's violet water.

While impression plaster sets in a comparatively short time, it is often desired to hasten this in order to reduce the period during which the impression must be held in the patient's mouth. Each batch of plaster should be tested as to time of setting, as this varies in different lots of the same brand.

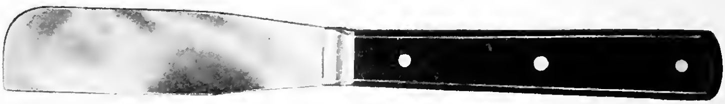
Several methods are employed to hasten the setting of the plaster. Potassium sulphate in powder or, preferably, as a saturated solution of crystals is effective. Chloride of sodium is used also for this purpose. Warm water also hastens the setting. Each of these methods may be

used, depending upon the grade of plaster and the time desired for the completion of the setting process. The method used by the writer is, first, to place five drops of the coloring material in a bowl, then a half teaspoonful of a saturated solution of potassium sulphate. The amount of water necessary for the average impression, from one to one and a half ounces, is then added. The plaster is now sifted in carefully until the water has been completely taken up by the plaster. Then the plaster spatula is cut back and forth through the mass to eliminate any air bubbles. Stirring the plaster will hasten its setting. The proper consistency of the mix for taking the impression is attained when the batter on the tray is thick enough to permit inserting the latter without danger of the plaster dropping.

PLASTER IMPRESSIONS.

Plaster Spatula and Bowl.—The form of spatula shown in Fig. 244 was designed to serve two purposes. It presents at its point two corners, one round and the other square. The round corner is used in mixing the plaster, and the other is best adapted for shaping up the cast on

FIG. 244.



Plaster spatula.

the glass slab. The plaster can be so shaped with it that there is very little need of trimming after it has hardened. The square corner is also useful and a great time saver in flasking, and will leave the plaster in proper shape to be varnished.

The plaster bowl made from rubber (Fig. 245) is now more generally used than that of porcelain or metal. The advantages of the porcelain

FIG. 245.

Rubber plaster bowl.

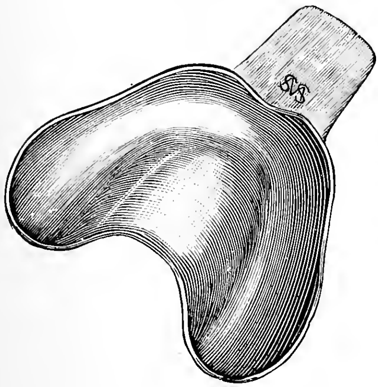
bowl consist in its firmness and smooth surface, there being less resistance to the spatula when stirring. Its great disadvantage is in the adhesion of the material to the porcelain, and the difficulty in its removal when allowed to harden in the bowl. The rubber bowl is flexible, but

is not as agreeable to the operator in handling. Its surface not being smooth, more resistance is offered to the movement of the spatula. The great advantage of the rubber bowl over the porcelain is the ease with which the plaster can be removed after it has hardened. It is also possible to squeeze its sides together and thus make a spout for pouring. This, combined with the fact that it is unbreakable, seems to have brought it into general use.

IMPRESSION TRAYS.

An impression tray is the receptacle by means of which the impression material is conveyed to the mouth, and by means of which it is

FIG. 246.



Full upper impression tray.

FIG. 247.

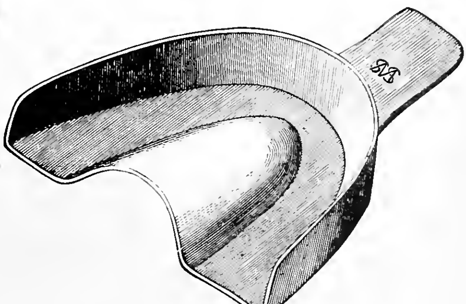
Full upper tray with deep flange for use with plaster.

brought into relation with the tissues of which the imprint is to be made. It also serves to retain this material in place until it hardens,

FIG. 248.

Full lower impression tray.

FIG. 249.

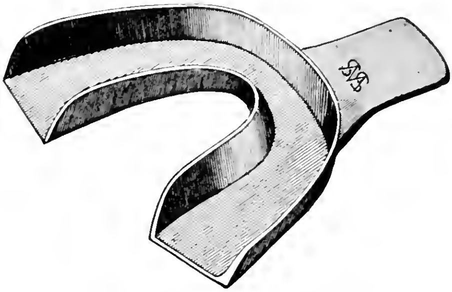


Tray for partial upper impressions.

and in some instances to remove it from the mouth. When an impression has been broken in withdrawing it, the tray serves as an accurate matrix into which these fragments may be fitted.

There are two kinds of impression trays in general use. The first is the cast tray, which is made of brittania metal or tin. The main advantage of this type is that it can very readily be bent and shaped to fit the case. The other style of tray is that made of German silver by

Fig. 250.

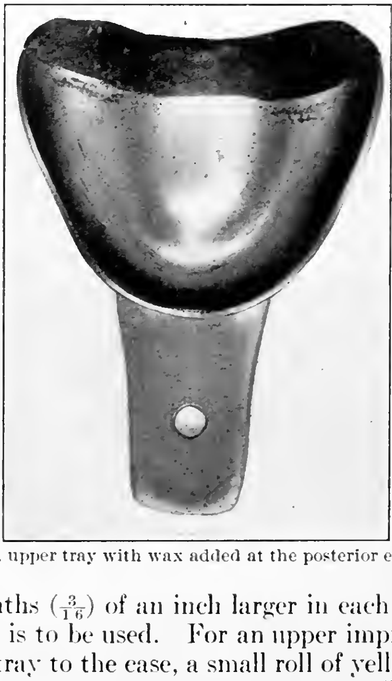


Tray for partial lower impressions.

swaging, and this is very strong and rigid. For typical mouths, where no bending or shaping is required, this type of tray is ideal.

In selecting a tray for an edentulous mouth great care should be taken to have it properly adjusted to the case in hand. It should be

Fig. 251.



Full upper tray with wax added at the posterior edge.

about three-sixteenths ($\frac{3}{16}$) of an inch larger in each direction than the mouth for which it is to be used. For an upper impression, in addition to conforming the tray to the case, a small roll of yellow beeswax should be placed on its posterior edge, and while this is still soft it should be placed in the mouth and pressed up into proper position. The wax will

then receive an impression of the parts posterior to those to which the denture will extend, and should then be trimmed down to leave a narrow rim of wax at the posterior edge (Fig. 251).

The object of this wax is to prevent the surplus of plaster from being forced beyond the posterior edge of the tray and thus nauseating the patient. With the wax properly fitted to the tray equal pressure upon the tissue may be obtained at the posterior surface, as at the buccal and labial surfaces. If wax be not placed on the tray, as described, an imperfect impression is almost certain to result.

A Method of Making a Special Tray.—In very difficult cases it is sometimes necessary to make a tray, as one suitable for the case in hand may not be found. An impression is taken in wax and a cast produced, and over the cast a sheet of wax one-eighth ($\frac{1}{8}$) of an inch in thickness is placed. A zinc die is then made, using the enlarged cast as a model, and a counter-die, with which a tray is swaged from German silver of about 22G. A handle is then soldered on with silver solder, and the tray should exactly fit the case.

CLASSES OF IMPRESSIONS.

Cases of which impressions have to be taken for the making of plate dentures may, for purposes of simplicity, be divided into four groups:

1. Simple edentulous cases (upper and lower), in which the jaw is typical and regular in shape, such as Figs. 252 and 253.

Fig. 252.

Cast of upper jaw of regular form.

Fig. 253.

Cast of upper jaw, of which impression is easily taken.

2. Complicated edentulous cases with jaw irregular in shape, such as upper cases with high palatal vaults, with cleft palates, or with very high maxillary tuberosities; cases in which part of the alveolar ridge has been removed; upper or lower cases in which there has been great resorption of the alveolar ridge, and where the muscular and fibrous attachments have become in consequence abnormally prominent (Figs. 254, 255).

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3. Simple partial cases in which the remaining natural teeth are parallel and stand in columns, and from which the gum has not receded. Cases,

Fig. 254.

Cast of upper jaw with large maxillary tuberosities.

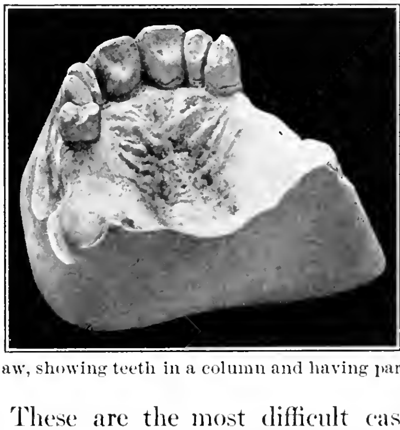
Fig. 255.

Cast of upper jaw with median bony tumor.

in short, in which it is possible to remove the impression from the mouth upon the tray (Fig. 256).

4. Complicated partial cases exhibiting dovetailed approximal spaces where the teeth have been lost, and cases in which the teeth themselves

Fig. 256.



Cast of upper jaw, showing teeth in a column and having parallel long axes.

are bell shaped. These are the most difficult cases of all, from the taking of the impression to the insertion of the finished plate (Figs. 257 and 258).

Taking a Full Upper Impression in Plaster.—When the patient is seated in the dental chair for taking an upper impression the chin should be on a level with the operator's elbow when the latter's arm is dropped at the side (Fig. 259). This gives full control over the field of operation and is the most convenient position for the various manipulations. A towel or bib made for the purpose is placed over the front of the patient's clothes to prevent injury from the plaster.

For an upper impression the plaster should be placed higher on the

anterior third of the tray (Fig. 260) and slope back to the posterior edge of the tray. With the left arm around the patient's head, the index-

Fig. 257.

Cast of lower jaw with isolated teeth not parallel.

Fig. 258.

Cast of upper jaw exhibiting several interdental undercuts.

finger is placed in the left angle of the mouth. The right distal corner

Fig. 259.

Proper relative positions of patient and operator for taking upper impressions.

of the impression tray is introduced into the right angle of the mouth (Fig. 261), and then by a rotary motion the left distal corner is carried

into the left angle, and the tray brought in so the handle occupies the median line. Then, holding up the lip so that the alveolar border is visible, the tray is pressed up so that the plaster will touch the anterior

Fig. 260.

Full upper tray with correct amount of plaster for taking an impression.

portion of the alveolar border first. Pressure is continued until the entire alveolar ridge has been covered with plaster and the air has been

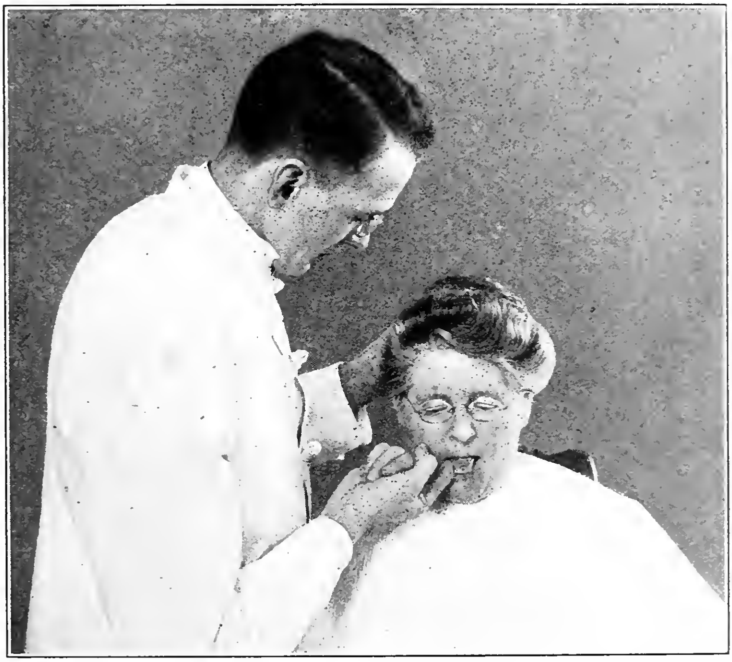
Fig. 261

Method of inserting the tray in taking an upper impression.

forced out at the rear, the plaster beginning to show over the posterior edge of the tray. Then, with the posterior edge of the tray held firmly up against the tissues, the anterior part of the tray is pressed up into

proper position with a slight oscillating motion, and the surplus plaster will be forced over its anterior and buccal edges. The cheeks and lips are then manipulated in such a manner that the plaster will be pressed well up on the buccal and labial sides of the alveolar process. The tray is then to be held firmly in position by pressure with the fingers upon its centre until the plaster sets (Fig. 262). While the plaster is in process of hardening the patient is instructed to lean the head forward, and, should signs of nausea be manifested, the request is made to breathe hard through the nose and to hold the tongue down quietly.

Fig. 262.



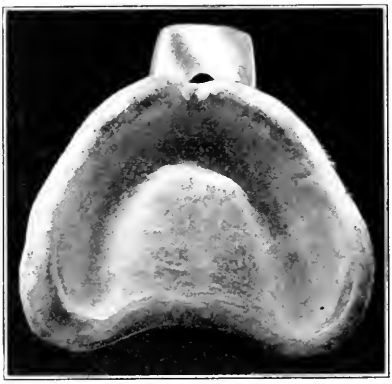
Correct method of holding an upper impression tray in place during the setting of the plaster.

If these suggestions are given to the patient, ordinarily there will be little trouble on the score of nausea.

After the impression has been properly hardened, if it cannot be easily removed by slight pressure upward on the handle of the tray, the finger is passed up under the lip to admit air over the edge of the impression, and in this way the adhesion is broken up and the impression can ordinarily be removed with ease. If, however, it should have been left in too long and found difficult to remove, then by the use of a water syringe, placing the nozzle over the edge of the plaster impression and injecting a small quantity of water on both sides of the mouth, the impression may be removed without further difficulty. A good impression should appear as in Fig. 263.

An accurate impression is absolutely essential to obtain satisfactory adhesion in the plate denture.

Fig. 263.



Full upper impression.

Full Lower Impressions.—The position of the patient for taking a lower impression is slightly different from that required for an upper.

Fig. 264.

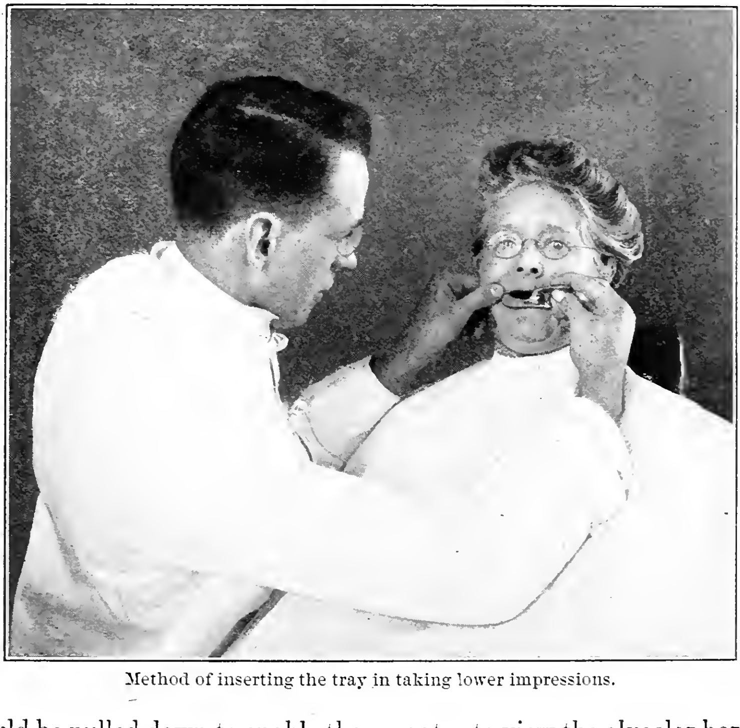
Relative positions of patient and operator for taking lower impressions.

The patient's chin should be as high as the operator's shoulder (Fig. 264), in order that the tray may be inserted with ease and that the operator may see clearly all parts of the field of operation.

The selection of the tray is, as has been previously stated, an important part of the operation. It must be selected for and fitted to the case. By "fitting trays" is here meant by mechanical means as well as by wax additions. After this is properly adjusted the plaster must be mixed thick enough to remain on the tray while it is being conveyed to the mouth. Sufficient plaster should be placed on a lower tray to enable the operator to press the soft tissues out of the way and still have plaster left to secure a perfect impression.

Standing in front of the patient, the thumb of the left hand presses back the right angle of the patient's mouth. The left side of the tray is carried well back into the mouth, and with a rotary motion the right side of the tray is carried to its place (Fig. 265). The lower lip

Fig. 265.



Method of inserting the tray in taking lower impressions.

should be pulled down to enable the operator to view the alveolar border, and with an oscillating motion (Fig. 266), produced by placing the index-fingers on the tray, with the thumbs under the chin, the tray is forced down into the desired position. The tray must then be held firmly in position until the plaster is sufficiently hardened to allow it to be safely removed (Figs. 267, 268).

In edentulous lower cases the jaw often exhibits at various places areas of hard and soft tissues. In such instances after the tray is fitted, an impression is taken either in wax or in modelling compound: this is removed and slightly enlarged and thus a perfectly fitting tray

Fig. 266.

Operator holding down lower lip and bringing the plaster in contact with alveolar ridge.

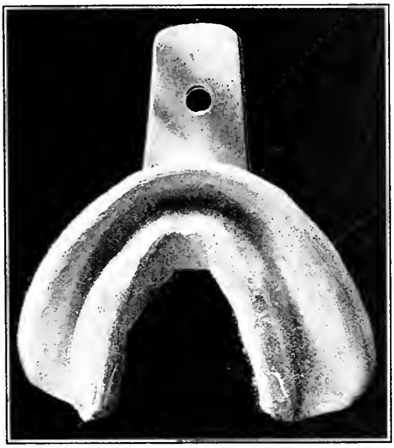
Fig. 267.

Holding lower impression tray in place during setting of plaster.

is secured. A thin coat of impression plaster is then placed over its surface, the tray returned to the mouth, and pressed into position. By this means an impression of excellent quality is obtained (Fig. 270).

The adhesion of the lower plate may be greatly increased by extending

Fig. 268.



Full lower impression.

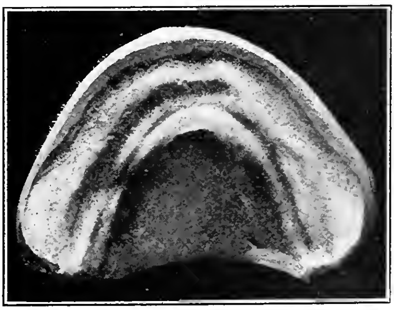
the lateral flanges to press upon the muscles of either side, thus increasing the possibility of its adhesion and adding firmness to the fixture.

Taking Partial Impressions in Plaster.—Partial trays differ in shape from those used for edentulous cases, as they are deeper and are designed to fit over the natural teeth. Each tray must, of course, be carefully

Fig. 269.

Cast of lower jaw with good alveolar ridge.

Fig. 270.



Cast of lower jaw with great resorption of the alveolar ridge.

fitted to the mouth before the impression is attempted. This should be done even at the risk of mutilating the tray and destroying its future value. The tray and plaster must be regarded as simply a means to secure a perfect cast, and should be treated as such, and there should be no hesitation in mutilating a tray by cutting or bending it to fit the individual case. When fitted the tray should be three-sixteenths ($\frac{3}{16}$) of an

inch larger in each direction than the jaw containing the natural teeth, to give sufficient bulk of plaster to enable the operator later to replace the broken pieces properly in position in the tray.

In taking a partial upper impression, the position of the patient is the same as heretofore described for an edentulous case. The tray having been coated with vaseline, to insure its separation from the plaster, and filled with plaster, is inserted into the mouth, as has been already described for an edentulous case. It is then pressed up until the natural

Fig. 271.

Double-end knife used in removing partial impressions: side view.

Fig. 272.

Impression knife: profile view.

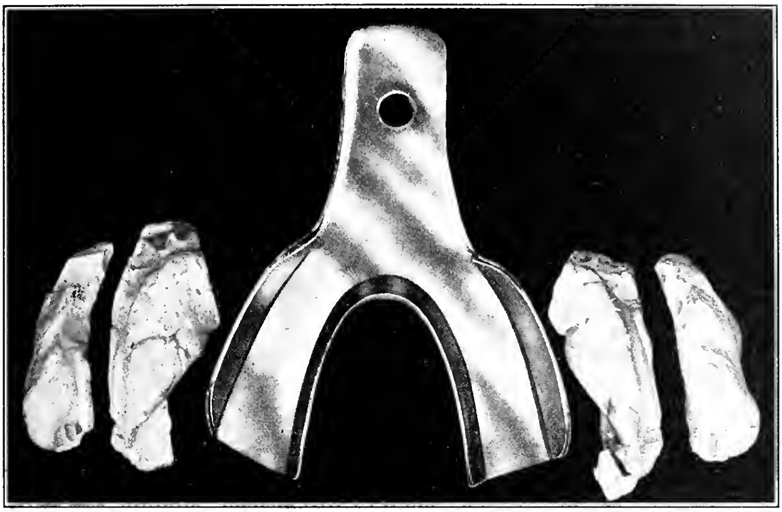
Fig. 273.

Small pliers.

teeth come in contact with its floor. The cheeks and lip are manipulated so the plaster will be forced well up on the buccal and labial surfaces of the teeth and alveolar process, and then the tray is held firmly in position until hardening of the plaster has taken place. The tray can usually be easily detached from the plaster, which, of course, is left in the mouth. The plaster has now to be removed, and this can be accomplished best by dividing it into sections. The knife shown in Figs. 271 and 272 will be found a useful adjunct to this operation.

With this knife a groove is cut in the plaster over the incisive edges of the anterior and the masticating surface of the posterior teeth, and over the alveolar ridges in the approximal spaces where teeth are missing. The knife is made strong, so that the operator can, after cutting a groove

Fig. 274.



Partial lower impression removed from the mouth in sections.

in the plaster, pry with its blade and thus cause the plaster to break and be easily removed. Vertical incisions should be made in the outer wall to divide it into several pieces, thus permitting the buccal and

Fig. 275.

Partial lower cast obtained from impression shown in Fig. 274.

Fig. 276.

Partial lower impression assembled upon the tray.

labial walls to be easily removed, and subsequently the lingual portion can be taken out in one piece.

A small pair of pliers, such as shown in Fig. 273, will be needed to remove the small particles of the impression from the mouth.

Partial Lower Impressions.—The method of taking a lower impression does not differ materially from that described for an upper. The tray is fitted to the mouth and vaseline used as before. When the plaster is mixed and placed in the tray there should be ample surplus. It is placed in position as described for an edentulous lower, and held firmly until the plaster has sufficiently hardened. After the tray is withdrawn a groove is cut over the posterior teeth, extending along the alveolar border, and the pieces so obtained are removed.

For cases where the six anterior teeth are in place and in good condition the operation of taking an impression is one of some difficulty. This type of case is one of rather common occurrence, and unless the tray is properly fitted the difficulties of the case are increased. That which is most desired is a correct impression of the partly edentulous jaw, the lingual surfaces of the anterior teeth, and a tooth on either side, which

Fig. 277.

Partial lower tray prepared for taking impression of cast with anterior teeth remaining.

may eventually be used for clasping. A perfect impression of the labial surfaces of the anterior teeth is not especially important, being of no value in fitting the piece. When a tray similar to Fig. 277 is used, no effort is made to secure a correct impression of the labial surfaces of the anterior teeth. If the surplus plaster is pressed over the labial surfaces it should be cut away, leaving, however, the teeth designed for future clasping intact. Having the labial portion of the impression cut away gives the operator an opportunity to build the plaster cast out as far as may be required to give the desired strength. In this way the cast will be many times stronger than if secured in the ordinary way.

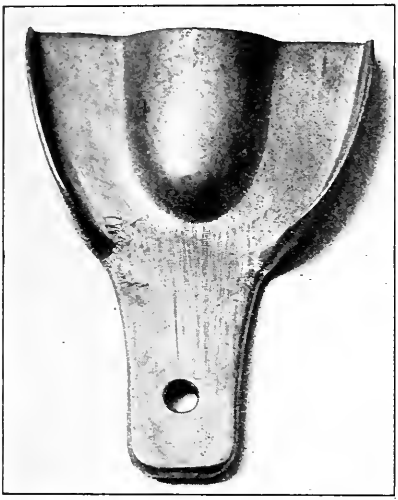
The upper tray should appear as in Fig. 278. When this tray has been fitted and the wax added it would present the appearance shown in Fig. 279.

In placing the impression plaster in the mouth, having the labial sur-

face of the tray removed enables the operator to perfectly see where to place the tray and press it into position until it comes in close contact with the teeth. When it is ready to remove, by pressing down on the posterior portion of the upper tray the plaster on the sides will break, the impression remaining in the tray. In the lower, press upon the posterior portion of the tray, and, with the exception of small pieces being broken at the sides, the impression will remain in the tray and may be easily removed.

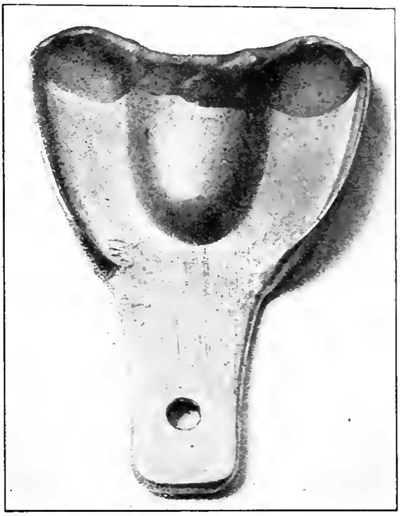
In some cases it is found extremely difficult to carry sufficient plaster on the tray into the mouth to secure a perfect impression. Especially

Fig. 278.



Partial upper tray prepared for upper case with anterior teeth remaining.

Fig. 279.



Tray shown in Fig. 278 with wax added to prevent plaster from being forced posteriorly.

is this true if there is a high palatal arch, or in partial cases where the remaining teeth have extruded to a considerable extent. This class of impressions, while difficult, is made comparatively easy by first placing as much plaster on the tray as can be comfortably inserted. Then, with the spatula, plaster is carried into the mouth and placed in the palatal vault. Then the tray is inserted, and the plaster in the tray will unite with that already placed in position and a correct impression should result.

CHAPTER VIII.

THE MAKING OF PLASTER CASTS.

By A. DeWitt Gritman, D. D. S.

After a plaster impression has been removed from the mouth it must be prepared for pouring the plaster cast. If it has been removed intact upon the tray, as is usually the case in full upper and lower impressions, it is only necessary to allow it to set thoroughly but not to dry out before it undergoes the several steps of this preparatory treatment. For reasons which will presently become evident, not more than half an hour should elapse before this is undertaken.

An impression that has been removed from the mouth in sections should, as a rule, be assembled in the tray. This affords an accurate matrix into which the pieces may be fitted. The broken pieces should have their surfaces carefully brushed, to free them from any small particles of plaster which may adhere to them. The brush best suited to this purpose is a soft bristle brush about half an inch in diameter. The camel's hair pencils frequently employed for this purpose are too soft and will not remove all the particles of plaster, and thus the surfaces cannot be accurately fitted together. The tray upon which the broken impression is to be assembled should also be perfectly clean and free from particles of plaster. The assembling should be done preferably within five or ten minutes after the impression has been removed from the mouth. If the impression has been allowed to dry a few hours its pieces should be moistened, as by so doing the broken surfaces may be more easily and perfectly fitted together.

Beginning with the largest pieces, as they are more easily joined by reason of the greater area of the fractured surfaces, these are carefully fitted into place in the tray. The smaller pieces can usually be placed in position later, although the fitting together of the pieces may require some change in this order of procedure. When the assembling has been completed, the lines of fracture should appear only as hair-lines. Each piece is to be waxed firmly to the rim of the tray as it is put in place by flowing melted yellow or adhesive wax at the joint between the periphery of the impression and the rim of the tray. No substance, however, such as wax, varnish, or plaster, should be interposed between the fractured surfaces, nor between the plaster surface and that of the tray to which it fits, as accurate joining of the parts would then be impossible. Nor should any wax be allowed to flow upon the surface of the impression which is to give form to the cast. Great care also should be taken to have the impression firmly waxed to the tray, so it will not be displaced while the plaster is being thrown out of the impression at the time the cast is poured.

Considerable care and accuracy are required to assemble the parts of a badly broken impression, and much patience is necessary to obtain satisfactory results. When it is remembered that only by attention to the minutest details of assembling can a perfect cast be produced, the profitable employment of time necessary to do this is made manifest.

SEPARATING MEDIA.

Before pouring the cast it is necessary to coat the surface of the plaster impression with some medium which will prevent the adhesion of the plaster of the cast to that of the impression. This medium must be of such a character as not to obliterate any of the details of the surface of the impression and yet permit its separation from the cast. Soap has been used as a separating medium for this purpose, being employed as a solution of one ounce of Castile soap in a pint of water heated until the soap is dissolved. A lather made by dipping a brush in water and rubbing it upon a cake of soap may also be applied to the impression. Thin liquid silex is also used as a separating medium. Collodion may also be used. The most satisfactory method employed at the present time is that of double varnishing the impression, using shellac and sandarac varnishes. By this method the impression is first varnished with a solution of gum shellac in alcohol, which serves to stain the plaster by soaking into its substance about a sixty-fourth of an inch, and establishes a line of demarcation between the impression and the cast, and thus reduces the danger of marring the cast when separating. The shellac serves also as a filler, infiltrating the surface of the porous plaster and rendering it non-absorbent for the sandarac varnish which is to follow. It should all sink into the plaster and should never be thick enough to glaze it. After two or three coats of shellac have been placed on the impression, and have thoroughly dried, the surface is treated to a thin coat of sandarac varnish. This serves to glaze the surface of the plaster, which in turn imparts a smooth surface to the cast. The sandarac is also the separating medium proper.

One of the most satisfactory ways to use shellac and sandarac varnishes is the method employed by the author, and that is to use them mixed in equal parts for the first coat and to use sandarac alone for the second coat. The advantage of this method is in the saving of time, as shellac and sandarac when mixed in equal parts will dry as quickly as sandarac alone. Great care should be taken to have the varnishes of the proper consistency. A very safe rule is to have them so thin that when placed on the impression the first and second coats will sink into the plaster, and not until after the third coat will there be any gloss on the surface of the impression. Varnish that is too thick will obliterate the fine lines of the impression and give an imperfect cast.

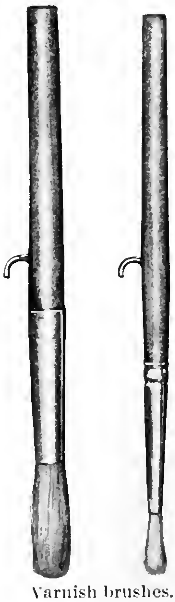
Two varnish bottles such as are shown in Fig. 280 will be found very useful containers of the media. The glass cap largely prevents the evaporation of the alcohol, which would result in a thickening of the varnish. Bottle No. 1 should contain sandarac and shellac in equal

parts, while No. 2 contains sandarac alone. Each should be supplied with a large and a small brush for applying the varnish (Fig. 281). These brushes should be hung, by means of wire hooks inserted in their shafts, upon a wire support stretched across the mouth of the bottle. The suspension of the brushes prevents their bristles being bent out of shape by the weight of the brushes upon them. Very soft bristle brushes will be found most satisfactory. The large brush is to be used for edentulous cases and for partial cases, except at the portions exhibiting the impressions of teeth. In these cases the small brush will be found very advantageous to carry the varnish down into the tooth impressions.

Fig. 280.

Varnish bottle with brushes hanging on wire support.

Fig. 281.



Varnish brushes.

From five to ten minutes after the impression has been removed from the mouth it may be varnished, first with No. 1 (shellac and sandarac), and five minutes later it will be dry enough to varnish with No. 2 (sandarac), and in five minutes more it will be dry enough for the next step.

Before pouring a plaster impression it should now be thoroughly soaked in water for not less than from three to five minutes. The objects of this soaking are threefold: first, it enables the plaster to flow freely over the surface of the impression, as plaster flows poorly over a dry surface; second, the impression does not absorb the water from the cast, thus allowing the plaster to harden naturally and to develop its greatest possible strength (a dry impression would absorb the water from

the cast and make it worthless); third, soaking the impression softens it, and it can be removed with greater ease and with less danger of breaking the cast.

Impressions of modelling compound receive no treatment preparatory to pouring the cast, save to be thoroughly wetted and to have the excess of water carefully shaken out. Wax impressions receive a very thin coat of sandarac varnish, which glazes the surface and permits an easy separation from the cast.

Plaster for Casts.—Casting plaster should be much coarser and stronger than that used for impressions, and should set in about twenty to twenty-five minutes. It should be the strongest and hardest plaster that it is possible to obtain.

The author has been recently using a plaster made by mixing a very coarse builder's plaster with a finer grade of casting plaster, and the casts obtained with it have been exceptionally hard.

POURING THE CAST.

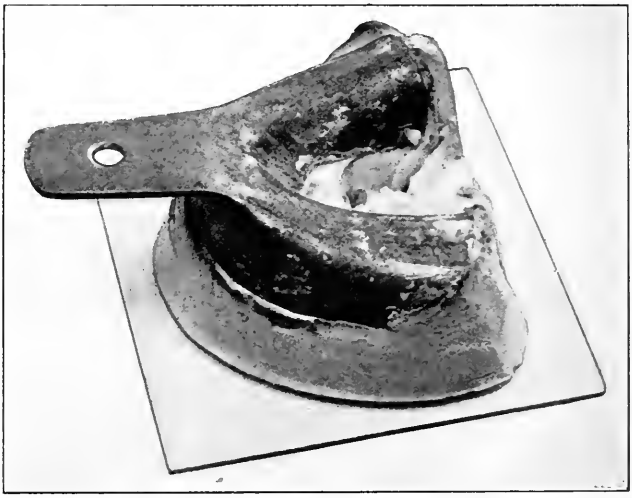
The technic of pouring the cast is the same, irrespective of the material of the impression, so one description will suffice for all. After the impression has been made ready the proper amount of water is placed in a plaster bowl and the casting plaster is sifted in slowly, so that each particle becomes saturated with water and settles to the bottom of the bowl. Nothing should be added to the water to hasten the setting of the plaster, as this will be at the expense of hardness in the cast. The proper amount having been added to absorb the water, the spatula is used to cut through the batter a few times to make the mix homogeneous. If the bowl is jarred on the table any air bubbles present will rise to the surface. It is infinitely better to do no stirring at all than to stir too much.

The operation of pouring the cast may be divided into two stages to correspond with the two objects in view in this procedure. In the first the surface is to be perfectly covered with the soft plaster. Accuracy in this step will, of course, determine largely the trueness of the surface of the cast, as any air confined next to the impression, or any water left in the tooth depressions, or any failure to have the surface covered with plaster free of air bubbles, will result in a corresponding defect in the cast. The second stage is simply to add enough plaster to give the cast proper bulk.

In pouring a full upper or lower cast, plaster is placed in the impression at one distal corner, and should follow the alveolar border around to the opposite corner. By slightly jarring the impression, as it is held in the hand, by striking the latter upon the work-table, the plaster is easily made to flow over the surface of the impression in a thin coat. Most of the plaster is then thrown out of the impression by inverting the tray and by jarring it slightly, leaving only a thin film covering the surface. More plaster is added. This is also largely thrown from the impression. This is repeated a few times until all traces

of air bubbles have been removed, and the thin film of plaster remaining on the impression is smooth. In an edentulous case the plaster is now added very carefully with the spatula, jarring each portion into place, until it is at least one-half inch thick in the thinnest place. A mass of plaster batter is then placed upon a glass slab, and the partly poured impression is inverted over it and pressed down on the glass slab until the cast is of the desired thickness, the size and shape of the cast being determined by the purpose to which it is to be devoted. The bottom of the tray should then be parallel to the glass, in order that the alveolar ridge of the cast may be parallel to its base (Fig. 282). The square edge of the spatula, shown in Fig. 244, is then used to shape up the cast for metal or for vulcanite work, as desired in accordance with the shape later to be advised for these two classes of work. A slab $3\frac{1}{4}$ by 4 inches of thick window-glass will be found very convenient for

Fig. 282.



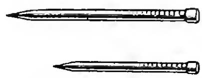
Lower impression poured and inverted on glass slab.

this work. When the cast has hardened, glass of that thickness can be bent by placing the index-finger in the centre of the glass and the thumb and the middle finger on opposite edges of the slab. By pressing down with the finger and raising up with the thumb the glass can be bent enough to break up its adhesion and separate it from the cast. The object of the use of glass for this purpose is to give a smooth glazed finish to that surface of the plaster which in the completed cast will be denominated its "base."

In pouring partial upper and lower impressions great care must be taken to remove all of the water and air from the tooth impressions. This is done by flowing the plaster carefully into the impressions of the teeth, and then by throwing it out by jarring the inverted impression. This should be repeated until all the air and water have been removed, leaving a thin film of plaster over the entire surface of the impres-

sion. Then plaster is added to the depth of one-half of an inch, care being taken that no air is confined in the impressions of the teeth. Steel brads, such as are shown in Fig. 283, are then placed in the soft plaster, from one to four in the impression of each tooth, with their points toward the incisive and masticating surfaces of the teeth. Then the proper amount of plaster is added and the cast is inverted on a glass slab and shaped up with a spatula, as already described. Steel brads for strengthening the teeth in partial cases are about fourteen or fifteen gauge, and about three-fourths or one inch in length. These are to be preferred to brass brads, as they rust in the plaster and its attachment to them is very secure.

Fig. 283.

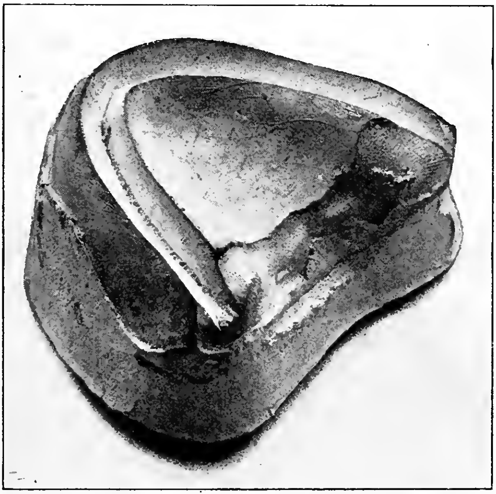


Brads used in reinforcing partial casts.

Removing the Impression from the Cast.—After the plaster has hardened from twenty to thirty minutes (depending upon the quality and the manner of mixing of the plaster) the glass slab is removed by bending it slightly. The edges of the tray are freed of the overhanging plaster, and then, by tapping the handle of the tray on its upper surface, this may be easily removed from the impression.

The next step is to remove the impression from the cast. If it be an edentulous upper or lower case, the operation is a very simple one.

Fig. 284.



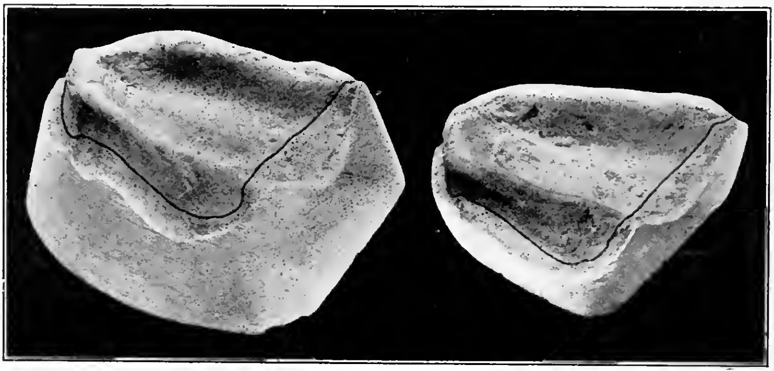
Tray removed from impression, and plaster of latter cut down to shellac stain.

First, the outer edge of the plaster of the cast is trimmed down so as to expose the outer edge of the impression all the way round and to release all undercuts. The impression is then cut down over the alveolar border until the warning yellow stain made by the shellac is reached (Fig. 284). A vertical groove is cut at each canine eminence. By tapping the impression with the handle of the knife gently over the entire surface, then by placing the point of the knife at the edge of the impression and pressing away from the cast, the buccal and labial portions of the

impression are removed. In a full upper case the palatal portion can be removed in a single piece. In a full lower case one or more grooves are cut on the lingual surface of the impression, and that portion can then be easily removed in sections.

In partial cases greater care should be taken in this operation, as the plaster teeth are very easily broken. The fact that the impression has been fractured in removing it from the mouth will be of great assistance in removing it from the cast. After the tray has been removed, and the border of the impression freed of the overlying plaster of the cast, the plaster over the incisive edges and masticating surfaces of the teeth is trimmed away very carefully until the shellac stain appears as an indication that the teeth are near at hand. Then the work should be directed to removing the plaster from about the teeth, so they will not be caught in the large masses of the impression and broken off when the latter are removed. The plaster should be chipped from about them until this danger is completely avoided. Especially about isolated teeth

Fig. 285.



Plaster casts trimmed: on left, for model for die; on right, for vulcanite work.

should the impression plaster be removed until they are free down to their gingival margins, before any attempt to remove the larger portions is made.

Trimming the Cast.—After the impression has been removed from the cast the next step is to mark the plan of the plate, and then the cast is to be trimmed to proper shape for vulcanite or metal work. The trimming is to give proper form to what are called the sides of the cast. The "face," or that representing the tissues, and the base of the cast obtained by contact with the glass slab have already been determined. The sides are determined by trimming away the surplus plaster. The use for which the cast is designed should be considered in giving form to its sides.

Casts for vulcanite work are trimmed so they are narrower at the base, and the face is trimmed to within one-eighth of an inch of the plate outline. This is in order that they may be set in the vulcanite flask without further cutting (Fig. 285).

Casts for metal work are trimmed so that they are broader at the base than at the face, in order that they may be withdrawn from the mold. The outline of the base should, in the first instance, be a reduced edition of the outline of the alveolar ridge; in the latter, it is to be an enlarged edition. The sides should have a uniform slope all around and be made quite smooth. The trimming should be done as soon as the cast has been freed of the impression, as the plaster may then be cut more easily

Fig. 286.

Plaster knife.

and with less brittleness than when it has dried out. If the trimming is deferred until this drying out has occurred, it may be better to first wet the cast, though it must be remembered that this unfits it for use until it has dried out again. It is generally considered better, however, to trim the cast without wetting, in which instance a coarse flat double-sided rasp will be of great service in shaping up the cast for use. The knife shown in Fig. 286 will be found a very useful pattern for this work.

CHAPTER IX.

DIES, COUNTER-DIES AND MOLDING.

By William H. Trueman, D.D.S.

The dies and counter-dies used in a dental work-room are reproductions in metal of that portion of a cast of the mouth over which it is desired to adapt by the process of swaging, a sheet metal plate or appliance. These dies and counter-dies differ from those used in the industrial arts for a like purpose in that they serve a temporary purpose only. As they are not designed to produce a large number of duplicates, they do not require to be made of a wear resisting metal. They are not required to produce upon the surface of the sheet metal a sharply defined embossed design calling for accurate adaptation of the die to the counter-die. All that is required is an accurate adaptation of the sheet metal to the surface of the cast, and as this surface is a series of easy curves and rounded elevations and depressions, the force of repeated well directed hammer blows is quite sufficient to accomplish the swaging. This being the case, the size and shape of the bodies of these dies and counter-dies is not restricted by the mechanism of a stamping press, and their construction is thereby very much simplified. If that part of the die, technically termed its face, is an accurate duplicate of the corresponding portion of the model, and the die is sufficiently rigid, and is convenient to handle, its size and shape in other respects is immaterial. The dies are made directly from the model by a process of open mold casting, and are usually made of zinc. The counter-dies are made by casting over the die a softer metal, and one with a lower fusing point to avoid any risk of union of the two by a partial fusing of the die. The object of using a softer metal for the counter-die is that it may, by a change in form during the swaging, become slightly larger than the die, and so accommodate itself to the thickness of the sheet metal. If the die and counter-die exactly fit, and are made of unyielding metals, they become a punch and matrix, and cut and tear the sheet metal instead of forming it into the desired shape. The dies and counter-dies of the sheet metal worker's stamping press, to avoid this, are so constructed that when the press is closed there is sufficient space between them to accommodate the metal used.

The process of constructing dies and counter-dies in the dental laboratory may be briefly stated as follows:—

The model is embedded in molding-sand contained in a tool termed a molding-flask. The model is removed, leaving a space in the sand known as the mold, into which molten metal is poured, producing a casting, the desired die. This is now embedded in molding-sand, only leaving exposed that portion which is to be included in the counter-die.

A properly shaped metal ring, a casting or molding-ring, is placed over it and molten metal poured in until of sufficient depth for the counter-die. We shall now consider in detail these various steps, and the materials and appliances used in the process of constructing dental dies and counter-dies.

METAL USED FOR DIES AND COUNTER-DIES.

A metal suitable for dental dies should possess the following characteristics:—it should be hard enough to withstand the force of swaging without marked bruising of its surface; it should be tough and not brittle, so that it will not break; it should neither contract or expand in passing from its fusing temperature to that at which it is used; finally, it should be readily fusible in the common heating appliances of a dental laboratory, and when molten should possess a quick fluidity, which shall permit of its flowing freely into small spaces. Of all the available metals zinc possesses these several features to the greatest degree, and is, therefore in general use for the making of dental dies. Much has been said and written on the evil effects of the contraction of zinc dies. Dr. T. L. Buckingham,[1] by a series of carefully conducted experiments determined that a bar of zinc five inches in length contracted in casting one-eighteenth of an inch, or one-ninetieth of its length. He estimated that a die two inches across and two and a half inches in length on the surface where the plate is to be made, contracted one-forty-fifth of an inch across and one-thirty-sixth of an inch in length. Such an infinitesimal change may be wholly disregarded.

The zinc of commerce contains impurities varying greatly in amount and in character which somewhat affect its physical properties when formed into dies. That sold as "the best," costing a few cents a pound more, will generally prove satisfactory.

The importance of properly caring for the zinc is not generally appreciated. To obtain the best results the zinc should not be overheated. If it is allowed to become red-hot, it never works quite so well afterward. It oxidizes rapidly at that temperature, and also alloys with the iron of the pot. These combined make it less fluid, it does not pour as well or make so smooth a die. The various remedies for this condition found in dental text-books have proved useless to the writer. The late Mr. Joseph Richards, an expert metallurgist and chemist of Philadelphia, invented and patented a method for improving oxidized zinc, which is used extensively and with satisfaction. He found that the addition of a very small portion of aluminum had a very marked deoxidizing effect and quickly restored the zinc to its normal condition.[2] An alloy is made of nine parts new zinc and one part aluminum. To the old and ozidized zinc, while it is in a molten condition, approximately one-twenty-fifth of its weight of this alloy is added, and the

[1] The Dental Cosmos, Vol. ii., p. 144.

[2] The loss of fluidity in zinc when subjected to a high temperature in melting is partly due to its alloying wtth the iron of the melting pot, a very small portion of iron producing a marked effect. The same loss of fluidity occurs during the process of galvanizing sheet-iron, in which the sheet iron is dipped into molten zinc; after a time the zinc looses its fluidity. Mr. Richard's method of restoring the zinc to a usable condition is largely used by those engaged in this industry.

whole thoroughly stirred. Its effect is quickly noticed, the zinc becomes more fluid, and the dirt and oxide separate. Small amounts are added, if needed, until the zinc is in a suitable condition for use, when it may be poured into ingots, or the separated dross removed and the metal immediately cast into dies. The aluminum acts as a deoxidizing agent, the amount needed is too infinitesimal to have any effect as an alloy, and the object in first alloying the aluminum with zinc is that it may be quickly disseminated throughout the mass. Cast-iron melting pots are preferable to those made of thin sheet-iron, as they do not so quickly become overheated, and are usually of a more convenient shape. Before being used, the inside of that designed for the zinc should be coated with a paste of whiting and water, well rubbed in. This should be renewed several times, or until the iron forms a protective coating of its own oxide. Unless this precaution is taken the zinc alloys with or eats into the iron, and in a little while makes a hole, usually where the bottom of the pot joins its sides. It is very important to keep one pot exclusively for the zinc, and another for the lead, and to have them so plainly marked that the mistake of using either for any other purpose is not likely to occur. They should be frequently emptied, and the oxide and dirt which collect at the bottom, and are non-conductors of heat, should be removed. When the molding-sand is sieved, and the scraps of metal found therein returned to their respective pots, any merely supposed to be zinc, or supposed to be lead, had better be discarded.

Zinc is not a desirable addition to lead used for counterdies, while zinc contaminated with lead is a very provoking mixture in a dental laboratory. A small portion of zinc unites with lead, forming an alloy that is no improvement over zinc for die making; the larger proportion of the lead, however, remains as a mere admixture, and the lead having a lower fusing point and a higher specific gravity, remains fluid after the zinc has set, and has a tendency to settle to some part of the face of the die. When this takes place, if the die remains in the mold until it has cooled below the melting point of lead, the lead forms a soft spot; if the die is removed from the mold at an earlier stage, the still molten lead runs out and leaves a vacancy; in either case the die is spoiled. The method this suggests for separating the two, *i. e.*, casting the mixed metals in a cone shape mold and overturning it as soon as the zinc sets, so as to allow molten lead to run out, and which is recommended by metallurgists, is very unsatisfactory in dental laboratory practice. With ordinary care the metals used for dies and counter-dies add so little to the laboratory expense account that it is economy to renew them when they are found to be in an unsatisfactory state.

Various alloys have been recommended for dental dies as preferable to zinc on account of being non-shrinking; perhaps the most noteworthy is a modification of Babbitt metal advocated by Dr. L. P. Haskell, of Chicago, with the following formula:—

Copper	1 pound
Antimony	2 pounds
Tin	8 pounds

Dr. Haskell contends for this alloy, in addition to its not shrinking, a decided advantage in its low fusing point. On account of a marked tendency of its components to separate, he directs that after it has been fully fused, avoiding, however, over-heating, it should be thoroughly and vigorously stirred with a wooden paddle until it is about to set, but still quite fluid, and then quickly poured into the mold. By this procedure the full advantage of the alloy is secured. If this is not done, the alloy quickly deteriorates and produces rough and unsatisfactory dies. For counter-dies he uses lead alloyed with a portion of tin to reduce its fusing point and increase its hardness. It is only with great care that lead alone can be used for making counter-dies over dies of this alloy.

The writer, after several years use of this alloy for the finishing die in cases retained by a vacuum-chamber, abandoned it, finding it expensive and troublesome, and of no practical advantage.

For small dies the various fusible alloys are extensively used, some operators prefer to make their working models of these alloys instead of plaster, because they are stronger and better able to resist wear; or as a time saver where in special cases the model is wanted quickly. Some fuse at so low a temperature that with care they may be successfully cast in modelling compound impressions.

For counter-dies, lead is generally used. The addition of tin has been recommended to increase the hardness of the lead. It is of doubtful value. It will generally be found most satisfactory to avoid complicating the routine of the workshop by adding materials seldom needed. In the few cases where lead proves too soft a metal for the counter-die, a second, or a third counter-die, for the same die, will, in most cases overcome the difficulty quickly; or in special cases a counter-die may be made of zinc, or a low fusing alloy.

A little more than a score of years ago a peculiar non-metallic compound known as Spence's metal was introduced for making dental dies. It is non-shrinking, melts at a low temperature, and is quite hard. Owing to its being rather brittle, these dies will not stand hammer blows; they can be used only in a press, and even then require to be protected by iron boxes, which form part of the press-mechanism.

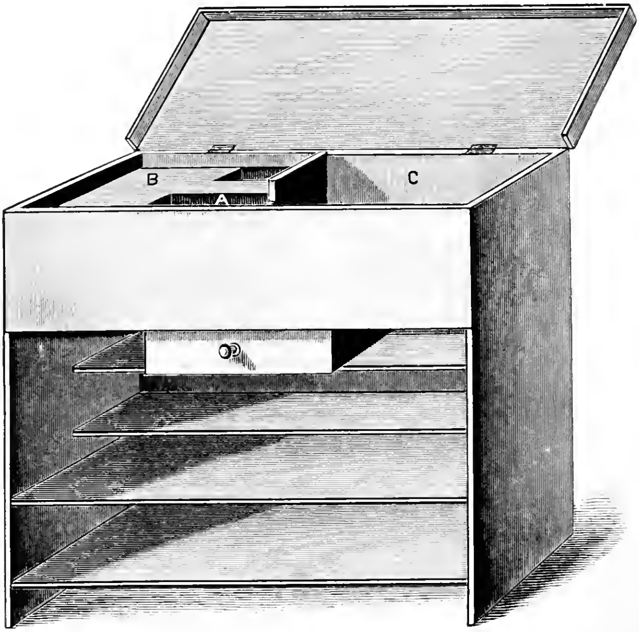
Spence's metal dies are of use only as finishing dies after the plate has been fully swaged in the ordinary way with zinc and lead dies. The fact that it has only been used to a very limited extent may be accepted as evidence that it is not of practical usefulness.

Lead having a lower fusing point than zinc, does not oxidize quite so rapidly, and is not so seriously injured by overheating, nor is it quite so sensitive to admixtures. While the accidental addition of a little zinc is no improvement, it is not a serious detriment. Various expedients have been recommended to prevent the lead oxidizing, or to reduce the oxide to a metallic state. The writer's experience with them has been unsatisfactory. Lead is inexpensive, and with care the waste is not a serious matter.

TOOLS AND APPLIANCES.

Where making metallic dies and counter-dies is a frequent operation, it is a convenience to have a bench especially designed for this work, such a one, for instance, as shown in Fig. 287. The box-like upper portion of this is divided into two metal-lined compartments; that at the right for the sand ready for use (C); between the two is located a solid block of wood upon which the molding is done (A); the compartment at the left is covered by a removable cast-iron tray, upon

Fig. 287



Molding-bench: *A*, Molding-block; *B*, iron tray; *C*, compartment for molding-sand ready for use.

which the molds are placed when ready to receive the molten metal (B); after the sand has been used it is passed into the box beneath through a square hole in the tray, to remain until the day's work is done, when it is sieved into compartment C, and damped so as to be ready for future use. A drawer is provided for the tools, and shelves for the metals, flasks, etc. These shelves should be covered with sheet zinc. As the molten metal is liable to be accidentally spilled into the upper compartments, they should be lined with copper. A wooden tray about two feet square, with a ledge all round about three inches high, and lined with copper, which may be, when needed, supplemented by an earthen crock to hold the sand, makes a simple and satisfactory arrangement when space in the work-room is limited. The tools used exclusively for molding are few in number:—

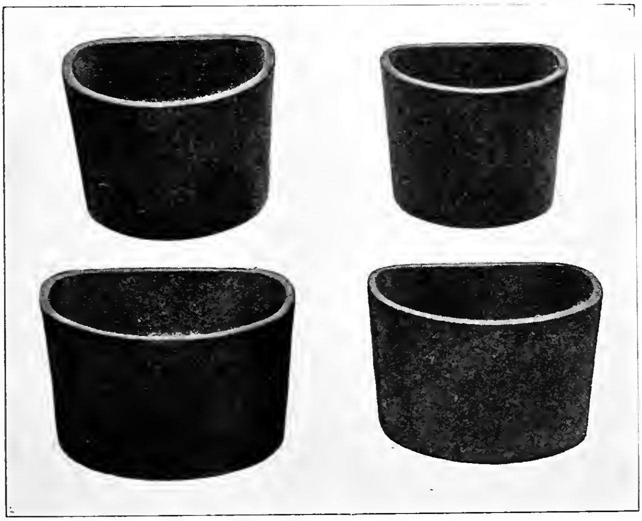
1. A Sieve.—This should have about twelve meshes to the inch, and to avoid rusting, should be made preferably of brass wire.

2. The Flasks.—These are boxes of wood or iron in which the mold is made. If made of wood, they may be from four to six inches square and four inches high. The wood should be half an inch thick, and well seasoned. The iron casting-rings sold at the dental depots in nests of four or five sizes are inexpensive and make by far the most convenient molding-flasks. (Fig. 288.) Now and again a model may be encountered too large for these, for which a larger box of wood may be provided. These iron casting-rings answer also for making the counter-dies. As they are liable to be broken now and again, it is best to have a liberal supply, at least four sets.

3. Trowels.—One or more small trowels, such as are used by iron and brass founders.

4. A Small Brush.—To brush the sand from the model or the die in molding and making counter-dies, a small round paint brush or a common shaving brush answers admirably.

FIG. 288



Set of cast-iron molding-rings.

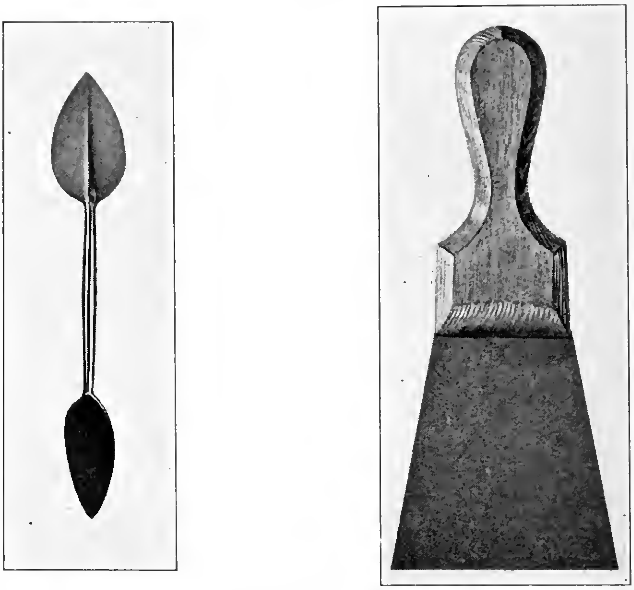
5. A Wooden Rule.—This should have straight edges, be from four to six inches long, and just large enough to be rigid, say half an inch wide and one-fourth inch thick. This is used to level off the sand in making the mold, and also to gently jar the model before attempting to remove it. The scraper shown in Fig. 289, suggested by Dr. A. DeWitt Gritman, is a convenient tool for this purpose also.

6. A Glass Tube.—This may be from six to eight inches long, and a quarter of an inch in diameter, and is used to blow out sand that may have fallen into the deeper portions of the mold.

7. A Point.—A worn-out four or five-inch half-round bench file answers admirably. The shank end, somewhat pointed, is used to lift

the model from the mold; the other end is often more convenient than a molder's trowel in repairing molds.

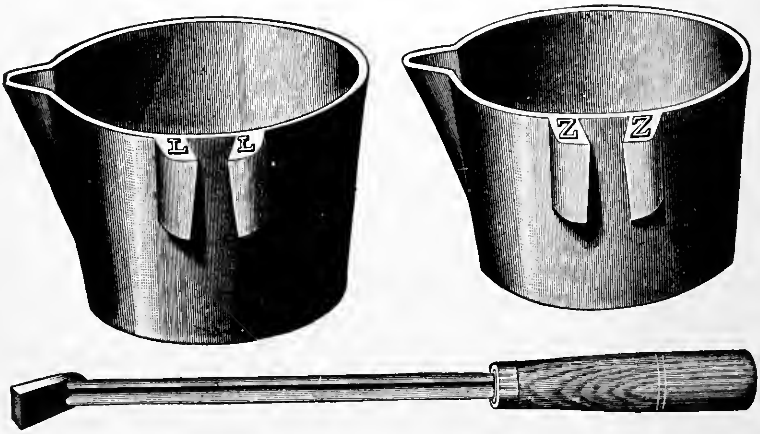
Fig. 289



Trowel and scraper useful in making molds.

8. **An Iron Spoon.**—The purpose of this is to remove the oxide or dross from the surface of the molten metal, or to remove it from the lip of the melting pot immediately before pouring.

Fig. 290



Melting pots for zinc and lead, with handle.

In addition to these, a camel's-hair pencil, a small hammer or mallet, a small cold chisel, and a good hack-saw are needed.

The necessary melting pots are referred to elsewhere. (Chapter I.) The importance of having separate pots for the lead and the zinc, and of having them so plainly marked that the one may not be mistaken for the other, cannot be too strongly enforced. There are many melting pots on the market lettered "lead," "zinc," but in letters so small that they are not readily seen after the pots have been some time in use. A marked difference in size or shape, that can be seen at a glance, is a bet-

Fig. 291

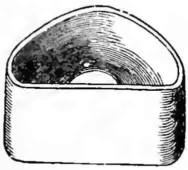


Fig 292

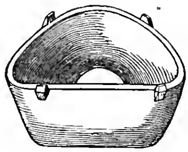
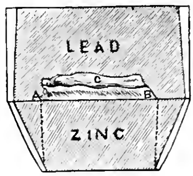


Fig. 293



Bailey's flask.

Fig. 294

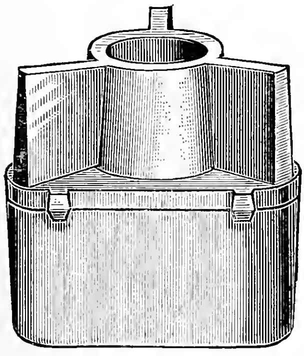
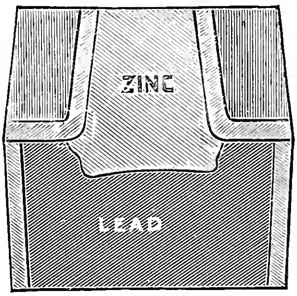


Fig. 295



The Lewis flask.

ter distinction. (Fig. 290.) The pot containing zinc will need renewing more frequently than that used for the lead. After a time the zinc seems to alloy with the iron on the inside where the bottom joins the sides, and the pot begins to leak.

The indispensable tongs for handling the melting pots, etc., is an important tool. Those usually found on the market made of malleable cast-iron are not trustworthy. To have the tongs break while carrying a pot of molten metal from the heating arrangement to the molding bench is a serious accident. A pair made to order of wrought iron by a blacksmith, who is informed of the use they are to be put to, will cost but little more, and will be lighter, more convenient to handle, and far more reliable. They should be from twenty to thirty inches long, of which length from three to four inches may be given to the beaks.

Among the various special forms of molding flasks designed to give a definite shape to the body of the die may be noted the Bailey flask, invented by Dr. Edward N. Bailey about half a century ago. The purpose of this flask is to provide a wide bearing, extending beyond the face of

Fig. 296

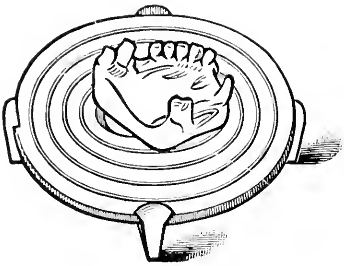


Fig. 297

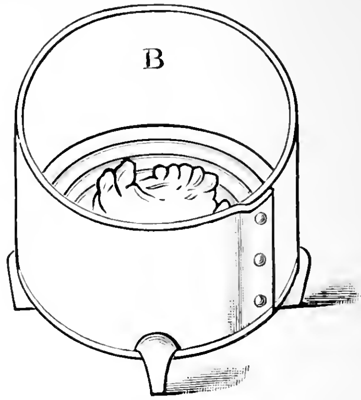


Fig. 298

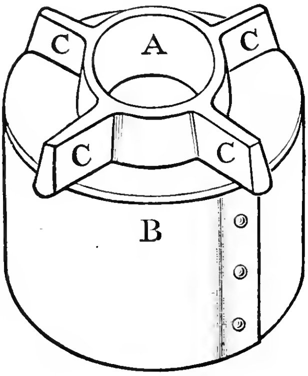
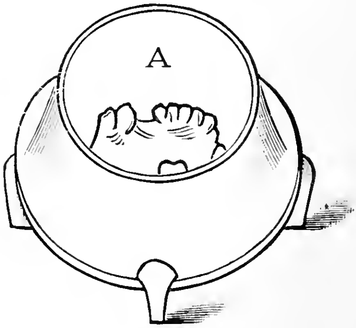
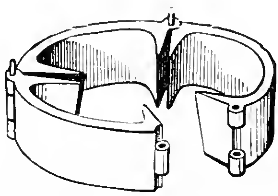


Fig. 299



The Pearsall flask

Fig. 300



Lower half of Hawes' flask

Fig. 301

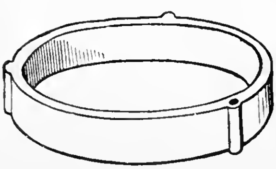
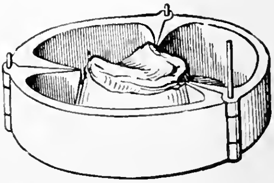


Fig. 302



Hawes' flask.

the die and resting upon the counter-die, to prevent the die tilting during swaging. (Figs. 291, 292, and 293.) A later device, the Lewis flask (Figs. 294 and 295), on the contrary, so shapes the body of the die that its contact with the counter-die is limited to the face, so that all the force applied in swaging is expended in forcing the die into the counter-die. A still later device, by Mr. W. Booth Pearsall, F.R.C.S.I., is a rather more complicated arrangement to accomplish the same purposes. (Figs. 296, 297, 298, and 299.) The practical usefulness of these devices is very questionable.

The Hawes sectional molding-flask, invented by George E. Hawes, of New York City, to facilitate making dies for cases with marked overhanging alveolar border, although complicated, is a practical device. (Figs. 300, 301, and 302.) To one who is expert in its use it affords opportunity of securing an accurate mold in these difficult cases more quickly than by the use of cores. It requires, however, careful manipulation to attain success.

MOLDING-SAND.

A sand for this purpose should be fine-grained enough to give a smooth surface to metals poured over it, and yet possess sufficient porosity when packed in a molding-ring to permit the escape of steam formed when molten metal is poured into a moist mold, and should form a mass of sufficient coherence to maintain a given form and to permit the withdrawal of a properly shaped model from it without fracture.

Several varieties of sand are used in the dental laboratory for making molds. The first and oldest is the finest grade of iron-founder's black sand; the second, the brass-founder's brown sand; and third, marble dust, or marble flour, made by manufacturers of fine plaster for building and art purposes. The last has, of late years, to a great extent supplanted the others. While it is no better, and in some respects perhaps not as good, it has the merit of being more cleanly. Within a few years, several substitutes for molding-sand have been offered by the dental supply houses, which are claimed to be superior to it in cohesiveness, more cleanly, to make a smoother and sharper mold, and not to require moistening before use. The origin and composition of these are trade secrets. While a little more costly than molding-sand or marble dust, in some localities they may be more readily obtained, and it can be said of them that they answer the purpose very well.

Preparing the Sand.—Upon the preparation of the molding-sand will depend much of the success of die-making. The sand should be moistened uniformly and sufficiently to give a sharp line of fracture when a mass made by squeezing in the hand is broken, and yet be in such a condition that it will readily pass through the meshes of a fine flour sieve. By far the best plan to obtain this condition is to moisten it, pass it through a sieve, and let it remain well packed in a covered box over night. When so treated it acquires a certain "mellowness,"

and greater cohesiveness, makes a smoother mold, and is less liable to cause bubbling when the hot metal is poured over it. If it is dry, and required for immediate use, it should be sifted so as to break up any hard lumps and to remove any fragments of metal or other foreign substances. Then water is added, a little at a time, thoroughly diffusing each portion throughout the mass before adding the next; when it seems to have nearly, but not quite enough, it is again passed through the sieve. If it is not sufficiently cohesive, add a little more water and repeat the process. Thoroughly working the mass by rubbing it between the hands or working it over with a trowel and sieving it, imparts the desired cohesiveness with much less water than if this is not thoroughly done. If made too moist, the casting will be spoiled by bubbling, that is, owing to the large amount of moisture present more steam is generated when the hot metal is poured over it than can escape through the sand, it therefore escapes through the metal in bubbles until the metal hardens sufficient to prevent this, then the steam raises the metal from the surface of the mold and makes an inaccurate cast.

There is an indescribable feel to properly prepared molding-sand when a mass is squeezed in the hand, with which the experienced molder becomes familiar.

It has been recommended to substitute oil for water in the prepartion of molding-sand, as the sand so prepared is always ready for use. This single advantage does not compensate for the dirty working of the material tempered by that medium. Its odor when heated by the molten metal is also objectionable. Glycerine, or glycerine and water is also recommended. It is far less objectionable than oil, and while sand prepared with it can hardly be said to be always ready for immediate use, it does not become unworkably dry so quickly, nor so thoroughly dry as when water alone is used, and is to that extent of decided advantage.

It is best to sieve the sand immediately after it has been used, and then to sprinkle over it enough water to keep it in a proper condition, and every night before leaving the workroom to see that it is damp enough to be in good working condition the next day. If it is allowed to become quite dry and the water added just before using, it is not so cohesive; the very dry portions do not take up water readily, and, although there may be more water mixed with it than should be, it will be friable and apt to make a rough mold; with sand in this condition a model which would leave the sand clean if it was in good order, will drag badly. On this account it is best to keep the sand in a water-tight vessel of earthenware or metal or metal lined, and tightly covered. In a wooden box it becomes dry at the edges, and with the small quantitiy usually found in a dental laboratory, this impairs very much its working properties.

PREPARING THE MODEL.

Apart from the manipulation which a plaster cast of the mouth requires to impart to it a desirable size and shape, more or less preparation is needed preparatory to the molding and casting process for

making a die. First, the outline of the plate or appliance for the construction of which the die is required and the position of the vacuum-cavity, clasps, etc., must be accurately traced on the model, in order to know how much of the surface of the model should be included in the metallic die. The model should be level, that is, its face and its bottom should be quite parallel; if it is not, it should be made so by adding to or cutting from the bottom. (Fig. 303.) This is important. If the model is not level, the dies will have the same defect, and no matter how accurate they may be in other respects, it will be a difficult task to form with them a plate that will fit. During the swaging process there will be a constant tendency to drive the plate toward that portion of the die lowest in the counter-die, resulting in a rock or spring very difficult to correct. Whether the

Fig. 303

Full upper cast prepared as model for a die.

model is high or shallow, is a matter of no moment, if it has sufficient strength. Regardless of the size of the plaster model, the die can readily be given sufficient mass for strength at the time of casting. As a matter of neatness and convenience, the model should not be much larger than is actually required. About one-eighth to one-quarter of an inch margin at the posterior line of the plate in full dentures, and the width of at least one tooth in partial cases and regulating appliances, is usually sufficient. The sides should slope slightly so that it will readily leave the sand. Fill up all acute undercuts not needed on the die that may tend to prevent the model freely leaving the sand, although they may be at points distant from the face of the model. If they are not essential parts of the model, fill them up with either plaster or wax; if they are, enlarge without deepening them, and without encroaching upon any portion of the model to be covered by the plate, give them a rounded form. A marked undercut due to a over-

hanging alveolar ridge, or at the lingual aspect of lower cases, may often be accurately reproduced in the die if so rounded as to leave room for a larger body of sand. Again, where this cannot be done, the undercut may be sufficiently reduced in depth by filling in with wax to permit an accurate mold to be made, and the full depth of the undercut restored upon the die in a few minutes with suitable cutting tools before the counter-die is made. If the form for a vacuum-cavity is desired on the die, this should be built up on the model with bees-wax, or bees-wax and paraffin, the wax being added drop by drop until of sufficient mass, and then carved with a wax knife to the desired shape and thickness. (Fig. 303.) Make its surface smooth, and to conform somewhat to the contour of the model; the sides slightly beveled so as to leave the sand freely, and when finished, make a shallow groove all round with a sharp point, accurately following the margin of the wax. This will facilitate swaging the margin of the vacuum-cavity to closely fit the palatal surface, and so increase its usefulness. Of the many methods from time to time recommended for producing a vacuum-cavity form on a metallic die, this is by far the simplest and most practical. With care and practice the form for the cavity can be neatly and quickly carved in wax so as to leave a sharp impression in the sand and has the further advantage, that any change in its form found necessary during the molding process is readily made, and the model itself is not marred or permanently injured.

It will frequently be found advisable to make additions of wax to prominent points of the model to be used for die making, because these may be bruised or slightly battered down in the swaging process. The points especially indicated are the rugæ in an upper and the top of a thin alveolar ridge in a lower model.

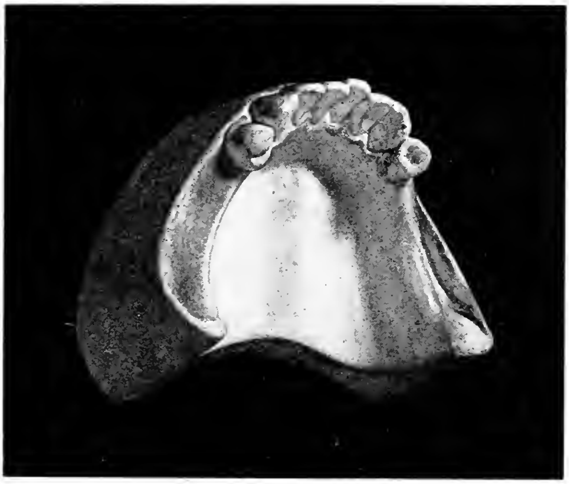
The preparation of models for partial cases is complicated by the presence of plaster models of the natural teeth. In some cases this is not a serious matter, in others it is quite so. In all but notably unfavorable cases it is well to first make a trial mold. Skillful manipulation learned only by care and constant practice, enables an expert to overcome many difficulties; there is an art in molding and casting which it is well worth a dental mechanic's efforts to acquire.

If the teeth lean, or are so shaped that the model cannot be withdrawn from the sand without displacing it so as to impair the accuracy of the mold, endeavor to correct this by so changing the shape of the teeth or the spaces between them by adding wax, that a satisfactory mold can be made. Judgment is needed to rightly place the wax, and care to trim it neatly and smoothly. The wax may be added a little at a time at such places as it is seen to be needed; it is better to do so than to add an unnecessary amount at the beginning. A very little will often accomplish the purpose, and not unfrequently the addition does not materially encroach upon the face of the die; where it does, however, correction should be made on the die by means of files and gravers before the counter-die is made. In extreme cases it may be permissible to break off the offending tooth or teeth, but

a careful workman will avoid this wherever possible. Mutilating the model to facilitate one operation too often invites a more serious complication later on. Now and again cases are met with where it is advisable to take a plaster impression of that portion of the model essential in the die, and from this make a new model from which the dies are made. It is well to bear in mind that any portion of a model broken off, especially a portion representing a natural tooth, can seldom be accurately replaced. Minute portions may crumble from the fractured surfaces, or foreign matter adhere to them, or the cement prevent close contact.

As a final preparation for the molding the model should receive a coat of thin quick-drying spirit varnish. Sandarac varnish is gen-

FIG. 304



Partial lower cast prepared as model for a die.

erally used for this purpose. An unvarnished plaster model has a rough absorbent surface to which molding-sand tends to cling. If it is necessary to add to or change the surface of the wax additions during the process of molding, a coat of varnish should be applied to the disturbed surface, and allowed to dry, before again using the model. This occasions, however, but a few moments delay.

MAKING THE MOLD.

Place the model on the bench with the back toward you and its face uppermost; place over it the flask, so that it occupies a central position, selecting a flask sufficiently large to allow a half-inch thickness of sand on all sides of the model. Now take up a handful of sand and sift it through the fingers upon the model, making it as fine as possible by rubbing it between the hands until the model is entirely covered; then with the fingers press it down firmly, packing it especially well be-

tween the sides of the flask and the model. After the model is covered the sand may be added more rapidly until the flask is full. Press the sand down firmly and evenly, but not too solidly. If it is not packed firmly enough, the mold will be rough, the model inclined to "drag", that is, it will not leave the sand freely, and the sand is liable to be displaced when the metal is poured in. If it is packed too solidly, the vapor caused by the hot metal will not be able to escape through the sand, and there is danger of the die being injured by its bubbling through the metal. The desirable mean between these two extremes can only be learned by experience.

When the flask is full, level off the surface with the wooden rule previously mentioned, or with a suitably shaped trowel, and, lifting the flask with its contents, brush away the sand from that part of the bench, and turning the flask over, carefully lay it down with the bottom of the model up. Next run the point, held at an angle of about 40°, all round the model, so as to make a bevel in the sand one-fourth of an inch deep and from one-fourth to one-half of an inch wide. Brush off the sand the point has loosened, or the flask may be raised and the sand thrown off by a quick motion, care being taken that the model is not disturbed. Now with the fingers press the sand firmly all around the model, and see that there are no loose particles to fall into the mold as the model is removed. Then take the point in the left hand, and resting the wrist firmly, place the point about the centre of the model, and with a small hammer gently tap it so that it will be driven slightly into the model, and thus make a handle with which to lift it from the sand. It need enter but very little to hold firmly enough for this purpose. Now carefully raise the model a very little, at the same time gently tapping the end of the point; if it does not readily leave the sand, let it fall back, and endeavor to humor it as it is slowly raised, so that it will leave the sand in the direction of least resistance. These manipulations must be made carefully and gently, or the model may be tilted or rocked in the sand and so make a false impression. In simple cases, if the flask is held with the model downward and gentle tapped, the model will fall out; in such cases hold the flask over a bed of sand that the model may not be injured by the fall. In more difficult cases, especially those for partial dentures, before attempting to remove the model, gently jar it by taking the wooden rule, and, resting one end of it against the edge of the model, at the front, for instance, having the other slightly raised, gently tap it with a small hammer or mallet; repeat this at the back, and then at the sides; then give the bottom of the model a few taps evenly distributed. These taps should be very gentle, they should not move the model: the object is to jar it so that it will readily part from the sand.

This jarring serves another useful purpose: the sand broken from the mold by an undercut or a leaning tooth may by this jarring be dislodged and fall so nearly in its proper place, that it can be accurately adjusted in position by the point, and securely held by letting fall a drop of water on the line of fracture. When this has been done it will not do

to invert the mold, any particles of sand that may have fallen in can be removed by a camel's hair pencil moistened by being dipped in water; when this is touched to the sand, the sand will adhere to it. Extra care will be needed in pouring in the metal to avoid displacing these fractured portions of the mold. Instead of filling the mold at once, pour in enough to nearly cover the fractured portion, then stop a moment to let the metal approach the setting-point, then add a little more, just to cover it, and in a few moments the operation may be completed. If this precaution is not observed, in all probability the broken portion will be floated from position and the die spoiled.

Having removed the model, observe if any sand clings to it on those portions included within the line of the plate. If so, before disturbing it, examine the mold; if that is not badly broken, proceed to consolidate the loose sand around the edge of the mold with the fingers, rounding the bevel made with the point, and being careful while doing so that no sand falls in. This accomplished, the flask may be carefully lifted, if it can in that way be more conveniently examined. First look for any fractured portions that may be restored, and make them secure; then note whether the sand brought out by the model seriously impairs its accuracy; if it should be at points readily corrected in the die, and the mold is otherwise satisfactory, it may be accepted. If, however, this is not the case, an effort may be made to dislodge the sand from the model without breaking it up and adjusting it to place in the mold. If these expedients fail, the mold must be rejected. Before proceeding to a second trial, note if any permissible changes in the model will overcome the difficulty. It is quite frequent that the first effort fails, and yet suggests some little change in the manipulation that makes subsequent efforts successful without any change in the model. A delicate sense of touch to quickly detect the point where the removal of the model from the mold is resisted, and judgment in overcoming the resistence, should be carefully cultivated. In some cases, as for instance, a partial upper denture with a deep vault and prominent rugæ, it is necessary to press the model forward and at the same time to lift it from the mold by raising the front first; a similiar movement will best serve for a full lower denture with a marked undercut at its lingual aspect. A full upper denture with a marked overhanging in front, requires the manipulation to be reversed. At times a broken mold can be repaired by adding sand to replace that broken away.

There are cases in which, despite repeated attempts, good molds are not secured. One class of these cases is formed of those having an overhanging alveolar ridge, particularly at the frontal portion. If the undercut is not too marked, the front of the model may be raised, bringing the axis of this portion of the ridge nearer to a vertical line. An inclined bed of sand is made, the front of the model resting upon its highest portion, the heel of the model upon the floor of the sand tray; it is enclosed by a molding-ring or flask, and the sand packed as before described. By this expedient the position of the model in the mold favors its removal in line with the projecting ridge. If the mold

is accurate, it is set on an inclined bed of sand so that the line, C, D is almost or quite horizontal as at A, B (Fig. 305), before casting the die. This may be modified by placing the model within the flask as usual, and making a chalk mark on the side of the flask accurately in line with the projecting ridge. When ready to remove the model, place the flask and its contents upon an inclined bed of sand so that the chalk line is vertical. After this has been accomplished the flask is restored to the floor of the molding bench. All the advantages of the first method are secured by the second, with the added advantage that the mold, in its relation to the flask, is more convenient for pouring the metal, and the cast will be level.

The undercut may be so marked that this expedient does not suffice. The device known as the Hawes flask is now in order. This device consists of two sections. Fig. 300 represents the lower section of

Fig. 305

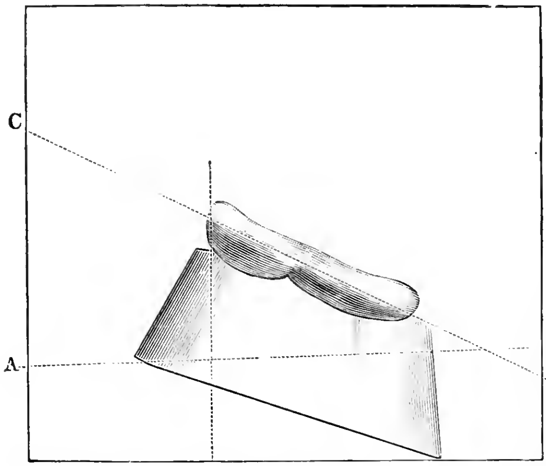


Diagram showing method of tilting model to avoid undercut.

the flask, slightly open, to show the joints; Fig. 301 is the upper section. When ready for use the lower section is closed and confined by a pin, and the plaster model is placed in it, as represented in Fig. 302. Slips of thin but stiff paper are placed between the jaws of the three flanges projecting inward toward the model, cut to approximately fit the sides of the model, and just touching it, to part the sand when opening the flask for the removal of the model. The model should be adjusted as to height so that the most prominent part of the alveolar ridge is about level with the upper edge of the flask. The sand is now packed into the space between the model and the flask until it is level with its upper edge, and finished off to a smooth even surface. As the mold is to be divided horizontally at this point, the level of the sand should be so adjusted that the edge next to the model is thick; this usually requires that the parting should be a little below the most prominent portion of

the ridge. Carefully remove all particles of loose sand from the face of the model and the finished surface of sand. The sand and face of the model must now be covered with dry, pulverized charcoal, sifted evenly over the whole surface. Molders keep it in a bag which they shake over the flask. When this is done, the upper section of the flask is placed upon the lower, three guide pins holding it securely in place while it is carefully filled with sand. It is then raised from the lower section and laid aside. The long guide pin is now withdrawn and the lower section carefully opened and the model removed. The lower section is then closed, the pin replaced, and the upper section adjusted, and the flask inverted. It is now ready to receive the metal. With this flask accurate molds may be made of models having quite marked projecting or overhanging alveolar borders; to accomplish this, however, some little practice and great care is required. The edges of the sand where the mold is divided are very friable and apt to be displaced in opening and closing the mold. It is, moreover, useful in few cases other than full upper dentures. On this account it is but little used. A more generally applicable method of overcoming such molding difficulties is by the use of cores.

In most cases two zinc dies are required, and two molds must be made. It not unfrequently happens that repeated efforts must be made before satisfactory molds are secured, and now and again one must be satisfied with the best that can be obtained and depend upon correcting the defects of the mold by carving the die cast in it. It may be a question whether it is best to do this or to spend a great deal more time in the effort to secure a better mold by the troublesome process of making cores. After satisfactory molds have been made they should be laid aside where they will not be injured before the metal is poured in. It should be remembered that a sand mold is quite friable, and becomes more so if allowed to dry. It is, therefore, prudent to make the casting as soon as possible.

In these difficult cases, as the labor of pouring the metal in the mold is but trifling, it is well to make several dies and select the two best.

CORE-MOLDING.

In cases where it is otherwise impossible to obtain a sufficiently accurate sand mold owing to sharp undercuts, leaning teeth, etc., recourse is had to core-molding. Cores are temporary additions made to the model which so change its shape at the points where difficulty exists that an accurate sand-mold can be made. These cores are in position on the model when the sand mold is made; they are then removed and placed in the prints they have made and then become part of the mold. They are made of a quick hardening plaster that can be molded to the model, has sufficient strength to bear the necessary handling, and will not interfere with the process of casting. Plaster of Paris, to which has been added about two-thirds of its bulk of either pulverized

pumice or soap stone, molding-stone, whiting, asbestos flour, or any similar substance that will mix with the plaster and enable it to bear a red heat without cracking or shrinking, is in common use in dental laboratories. The investment materials recently introduced are admirable for this purpose. In order to avoid bubbling[1] the cores must be thoroughly dried or baked before the molten metal is brought in contact with them, and as the sand molds must be used very soon after they are made, the core material must admit of this being done quickly without change of bulk or shape. The drying is conveniently done over a gas flame, or by means of the blow-pipe, care being taken, however, not to burn off or destroy the sharp edges. This is usually done after the mold has been made, as the baking make the cores friable and easily broken, or if this is avoided by careful handling, if the cores are long in contact with the damp sand, they may take from it sufficient moisture to bubble as freely as though they had not been baked.

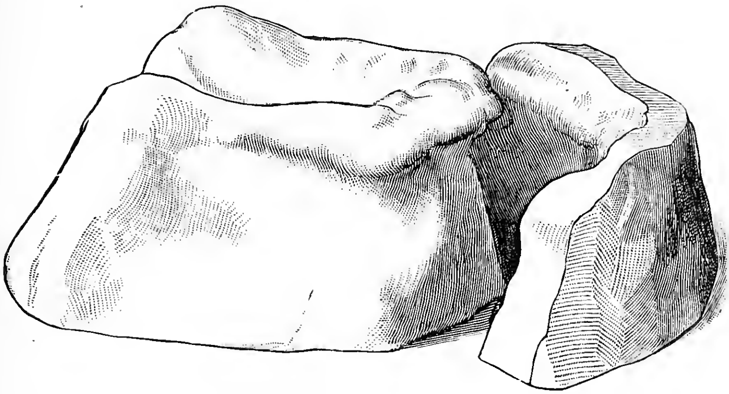
Whatever is added to the plaster used in making cores must be in a fine powder, free from lumps, and must be thoroughly mixed with it. The usual precautions of first preparing the model by varnishing or oiling, that the material of the core will not unite with it, must be observed. While cores must extend as far as needed to facilitate molding, it is desirable to keep them as small as is consistent with strength and their ready replacement, and to so shape them that they will leave in the sand an impression that will hold them accurately and securely in place when the metal is poured into the mold. As these cores when baked are light compared with the metal, unless securely held, they are apt to float out of position when the casting is made. To prevent this the metal should be poured in the mold slowly, a little at a time, so that the first portion will have commenced to set and assist in holding the core in place before the mass of metal is added, and yet this must not be done so deliberately that the various portions do not unite as thoroughly as though the pouring was continuous.

Cores are needed for models of edentulous upper jaws more frequently on account of a marked overhanging ridge. In these cases it is usually best, and is usually practicable, to make one large core to embrace the front of the model so far as the overhang extends, as shown in Fig. 306. Occasionally, however, the depression of each side may be so marked that it is necessary to divide this on the median line. Occasionally, a core may be needed for a very deep vault, but they are not, however, very satisfactory. A slight displacement of a core from this position seriously impairs the accuracy of the die, while a like displacement in any other position would be of little moment. It is generally best to accept the lesser evil of judiciously adding wax to the model until a sand mold can be made. The resulting inaccuracy seldom proves a serious fault, as close adaptation of the plate is not imperative in this position, indeed, in some cases it is not desirable. Models of the

[1] When hot metal is poured into a mold, any moisture present is converted into steam, and this escapes through the sand. The material of which the cores are made is too dense to permit this; it therefore bubbles or boils up through the metal, and usually spoils the die. To avoid this, the cores are thoroughly baked at a heat higher than that of the molten metal.

lower edentulous jaws with a marked inward lean of the ridge may require cores to secure accuracy of its lingual aspect. In such

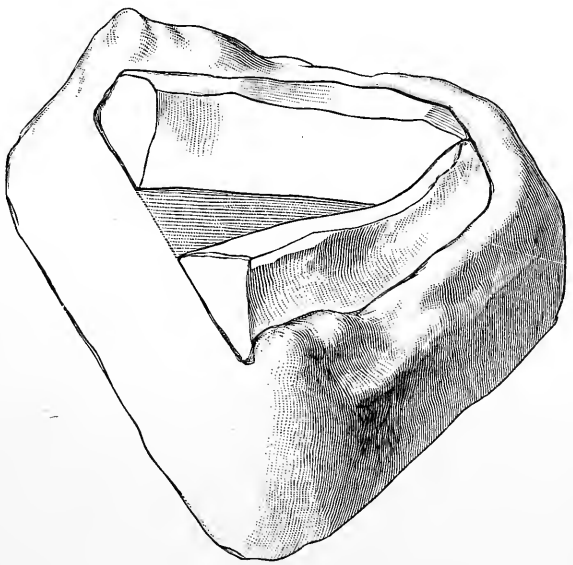
FIG. 306



Full upper model with alveolar undercut, showing form of core to fill in undercut.

cases it is usually best to make the core in two sections shaped as shown in Figs. 307 and 308, so as to permit of their removal without

FIG 307



Full lower model with lingual alveolar undercut, and core in two pieces in place.

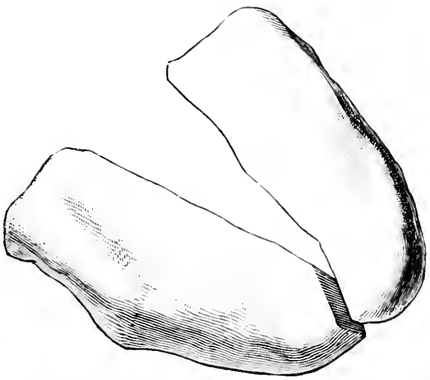
injury to the model. The conditions calling for cores in partial cases of either jaw are so various that only general instructions for making them can be given. They should be so arranged that they can be readily

removed without injury to the model; they should be as small as is consistent with the correction of the trouble requiring their use and their secure adjustment in the mold. Thin edges of either the core or the sand mold are to be avoided, and the general shape should be such that they can be accurately replaced in the mold.

Now and again, especially with models for partial lower cases with leaning teeth, it is expedient to let the core take the form of an impression in sections. The separate portions accurately united and held together with adhesive wax applied on the inside, form a mold to be imbedded in a mass of the same material of which they are made. This is thoroughly dried and the metal poured in. For convenience, just before pouring this mold may be imbedded in molding-sand, and a casting-ring used to give the die a proper size and shape.

At times, it is better in such cases to take a plaster impression of the model in sections from which to make a new model of that portion

Fig. 308



Under view of two-piece core for full lower model shown in Fig. 307.

to be covered by the plate, and from this to remove the teeth. This simplifies very much the making of the dies. The plate is made on this new model, the portion extending upon the teeth being afterward added in the form of soldered-on collars, made and adjusted to the original model. In some cases of marked leaning teeth very firm in position, exact accuracy is not required, as an accurately fitting plate cannot be forced over them.

Theoretically, cores offer a ready means of obtaining accurate dies of difficult cases. Practically, however, they are troublesome, and very uncertain. It is much better if a die sufficiently accurate can be obtained without them, even though the file and graver must be freely used to correct the short-comings of the casting. The actual manipulation of making cores differs in nowise from the usual plaster working of the dental laboratory. The plaster should be applied to the model neatly, and be confined to that portion requiring a core. When fully set, it should be removed, carved to proper shape to freely part from the sand mold

and to leave an impression favoring its accurate replacement. All the outer surfaces should be made smooth and then varnished.

CASTING THE DIES.

When ready to begin casting, the molds are arranged on the casting bench in convenient positions for pouring the metal. Suitable casting-rings should be close at hand, together with a supply of molding-sand with which to close any openings between the molds and the casting-rings through which the metal might escape. The metal having been fused in the melting pot, is brought to the bench. With an iron spoon, or some such tool, remove any oxide or dirt floating on the surface of the metal, especially from near the lip of the pot. If the metal is very hot, it is best to delay pouring until it has somewhat cooled. It is desirable that the metal shall quickly set when poured into the mold, so that its principal shrinkage shall take place in the centre of the mass. Pour the metal in a gentle stream into the mold at one of its back corners, holding the lip of the melting pot as close as possible to the sand. If the metal is poured in from a height, or in too heavy a stream, the sand of the mold is liable to be disturbed and the die rendered thereby rough and inaccurate; on the other hand, the pouring must be done quickly enough for the metal to flow into position before being chilled.[1] When the sand mold is filled, if the die is not thick enough, immediately place over it a casting-ring, the largest end down, pressing it gently into the sand so that the metal will not escape under it, and continue the pouring until enough metal has been added. A little sand packed around the outside of the ring will quickly arrest a flow of metal under it. If bubbling occurs, stop pouring for a few moments when the mold is about half full, and just before the metal in the mold begins to set, pour in more metal, holding the melting pot at a little height over the mold. If the bubbling has been slight this will frequently save the die; if, however, it has been quite marked the die is usually worthless. It is time saved to have the melting pot large enough to hold sufficient metal for several dies, and to pour several from the one melting. When the dies are fully set, turn them out of the mold, and examine their condition. Zinc, when quite hot is far easier to work than when cold; expert workmen take advantage of this by cutting off the teeth of dies for partial cases with a pair of large wire cutters, or a cold chisel, or hack-saw, and with file and gravers roughly correct any inaccuracies that may be noted. This can readily be done while the die is far too hot to handle by holding it in the large bench vise, and much

[1] Dr. A. DeWitt Gritman, of Philadelphia, suggests the following method of casting zinc dies: He does not empty the zinc pot, but keeps it at least about one-third full at all times, so that there is always a quantity of zinc in immediate contact with the walls of the pot. This more promptly melts than would a mass not in contact, and the pot does not become overheated. He begins to pour the metal when sufficient is melted to partly fill the mold, then returns the pot to the fire until another portion is melted; this he pours, and continues to melt and pour until the casting is complete. By this procedure the zinc is never overheated, but is poured at as low a temperature as possible, and may be used for years without deterioration. He claims also that there is less shrinkage on the face of the die. Care is needed that the portion poured does not chill before another portion is added.

time and labor are saved. When cold, the die is critically examined, and any corrections needed before making the counter-die are now made. If for a partial plate, the teeth may now be cut from the least desirable die, or this may be deferred until after the counter-die has been made. Any places where wax has been added to facilitate making the mold should now be corrected by cutting out the zinc to make it conform to the model. Inaccuracies due to imperfect molding on that portion of the die to be covered by the plate will also need attention. Spaces between teeth, undercuts, and the margin of vacuum-cavities, should be carefully compared with the model, and made to correspond as nearly as possible. In making these corrections the cold chisel may be used where much has to be removed; as a rule, however, the files and gravers, and occasionally a bur in the dental engine, will prove effective tools. It is just as important not to remove too much as it is to remove enough, and very important not to encroach upon any portion of the die that does not need correction. When these corrections have been made, casting the counter-die will be next in order.

CASTING THE COUNTER-DIES.

In making a counter-die three points are to be considered regarding its office during swaging:—First, it is to force the plate into contact with the die; second, to accomplish this it must hold the die in position; and third, it must by its shape and mass make for the die a solid foundation. It must take in all the face of the die that is to be covered by the plate, and sufficient beyond this to prevent the die changing its position. This usually requires that it shall extend about half an inch over the sides of the die. In mass, it should be a full half inch thick over the most prominent portions of the die. Convenience of handling and an eye for neatness will suggest that neither die nor counter-die should be unduly massive; they should, however, be properly proportioned to the size of plate to be swaged, and well able to bear without breaking or change of form, the impact of a heavy hammer.

The first step in making a counter-die is to place the die in a casting-ring, face up, elevated by packing sand beneath it until the plate line is about one-fourth of an inch above the edge of the ring. In cases in which the plate is confined to the face of the die, as in partial plates, the dies should be from one-half to three-quarters of an inch above the ring. The die will extend into the counter-die just as far as it extends above the ring. While it is necessary that it should extend into the counter-die sufficiently far to be firmly held in position, if this is overdone, it will prove embarrasing in separating the die and counter-die and in removing the plate from the counter-die after swaging. After the die is adjusted as to height, see that its face is quite level, and then firmly pack molding-sand between the die and casting-ring, filling the space solidly. With a point or small molding-trowel, smooth off this sand level with the top of the ring. After carefully removing any sand that may have fallen on

the face of the die, place over it, large end down, a casting-ring just large enough to leave about one-half of an inch of space all around the die.

The die is now ready for casting the counter-die. While there is a fair margin between the fusing temperature of lead and of zinc, they will unite if the lead is poured too hot. If all the lead in the pot is molten, it is safe to conclude that it is too hot to be safely poured over the die. It is best to wait until, on tilting the melting pot, the metal is seen to cling to its sides. When this condition has been reached, the metal is poured into the ring until it is about half an inch thick over the most prominent portion of the die. As in making dies, time is saved by arranging on the molding bench as many dies as are to be covered and pouring a number in succession. After the counter-die has set, the die and counter-die are removed from the sand, the casting-ring removed, and after brushing from them the loose sand, if needed immediately, they may be chilled in cold water. Before separating the die from the counter-die, if two have been made from the same model, one set should be marked by a hammer blow on the edge of both die and counter-die so as to know to which die each counter-die belongs. The die and counter-die are readily separated by a few sharp blows on the die with the swaging hammer in a direction to drive the die out of the counter-die. In most cases they fall apart readily; in some cases, however, where there are undercuts, they must be cautiously coaxed apart by light blows first on one side and then on the other, otherwise the die may be broken and ruined.

The dies should now receive a careful inspection, and the final preparation for use. Where two have been made from the same model, the best is reserved for the final swaging. If not previously done, the teeth should be cut from the first die used for partial plates, and any carving necessary to correct inaccuracies completed.

LOW FUSING ALLOY DIES AND COUNTER-DIES FOR SPECIAL USE.

Now and again, the so-called fusible metals can be advantageously used for making dies and counter-dies. Dies for small plates to be made of thin, soft, high carat gold, may be made of these low fusing alloys cast into plaster or moldine impressions of that portion of the model which the plate is to cover, the counter-die being also made of the same alloy, saving not only time, but the expense and trouble of melting the less fusible metals. In repair work, the low fusing alloy may be cast upon a gold, silver, or vulcanite plate with perfect safety, when a die is needed to fit a re-enforcing piece to an irregular surface. It may, in some cases, be cast upon a plaster model direct, thus making the counter-die first, the die being made by using it as an impression. While dies and counter-dies of low fusible alloys are not hard enough for serious work in swaging, and are too brittle to withstand heavy hammer blows, they, nevertheless, serve a useful purpose in forming

soft and pliable metals. Instead of using a hammer, the swaging may be done between the jaws of the bench vise, or in the "shot-swage." To get the best results with low fusing alloys they should not be overheated, nor yet poured when quite fluid. Just before setting they assume a plastic condition, and then make a harder and smoother die. In order to prevent the two dies from uniting when both are made of low fusing alloy, the first cast should be quite cold, and the alloy used in making the second casting should be as cool as it can be poured. Painting the surface with whiting is helpful, but unnecessary, if proper care is observed.

CHAPTER X.

SECURING THE VARIOUS DATA TO BE USED IN CONSTRUCTING ARTIFICIAL DENTURES. TAKING THE BITE. ARTICULATORS.

By Charles R. Turner, D.D.S., M.D.

In addition to the plaster casts which represent the jaws of the patient, other data are, of course, necessary for the design and construction of artificial dentures. These casts must be placed and maintained in the same relative position to each other during the subsequent stages of arranging the artificial teeth in occlusion as the jaws they represent are to occupy when the finished dentures have been inserted and are brought into occlusion. We have seen in Chapter IV. that when the natural teeth are in the mouth the so called "position of occlusion" is fixed by a certain definite fitting together of the occlusal surfaces of the teeth. When the natural teeth have been lost, the position of occlusion no longer exists, and it is necessary to determine for the mandible by considerations presently to be discussed a position in relation with the maxilla which will answer the requirements of an occlusal position for the artificial dentures. The operation of securing a record of this relationship in accordance with which the casts may be mounted upon an articulator, an instrument designed to maintain them in it, is commonly called "taking the bite."

Besides the securing of a record of this relationship, it is necessary to obtain also an estimate of the fulness which the artificial dentures must possess to restore the external contour of the lips and cheeks, and to record both the location of the median line of the mouth and the amount of the dentures which will be displayed during the ordinary movements of the lips in laughter and speech.

But it is not enough that the artificial teeth shall occlude properly; they must also be arranged to be capable of functionating to the best advantage during the various mandibular movements in which the food is masticated. This necessitates during their arrangement the use of a so-called "anatomical articulator," an instrument which is capable of reproducing the movements of the mandible of the person for whom the dentures are being constructed. The instrument must be adjusted so that its joint mechanism reproduces the temporo-mandibular joint of the case in hand, and hence the movements of the mandible. A record of the path of the mandibular condyles during these movements or its equivalent is therefore necessary. In order that the casts may be mounted upon such an articulator in the same relationship to its joint mechanism as the jaws they represent bear to the temporo-mandibular joint, a record of this relationship must also be obtained.

As a matter of convenience, it is usually customary at this time to select the shade of artificial teeth suitable for the patient under consideration in accordance with principles to be outlined in a succeeding chapter.

To recapitulate, the data which are to be obtained are:

1. Relationship of the jaws in the position of occlusion.
2. Fulness of plates necessary to restore external contours.
3. Median line of mouth.
4. Amount of dentures displayed in movements of lips. (High lip line.)
5. Relationship of the jaws to the temporo-mandibular joint.
6. Movements of the mandible.
7. Shade of artificial teeth.

These are usually included under the term "taking the bite," which by an extension of its old meaning has now come to commonly cover these several operations. It originally referred to the first of these procedures, which, as first in point of time and probably of importance, is now to be discussed.

SECURING THE RELATIONSHIP OF THE JAWS IN THE POSITION OF OCCLUSION. TAKING THE BITE.

If it were required to make an artificial denture for an edentulous case immediately after the teeth were lost, and if it were possible to obtain a record of what the occlusal relationship of the jaws was before the loss of the teeth, this would of course serve for the setting up of the artificial teeth, and the dentures would then establish the mandible in a correct occlusal position. As no data are obtainable which will enable the dentist to tell what this was, and as the changes in the tissues following the loss of the teeth soon alter the requirement of an occlusal relationship of the jaws for artificial dentures, an occlusal position for the mandible must be determined by the considerations now to be discussed.

When the teeth have been lost, the position of the mandible is determined by the balance established between the muscles which actuate it within the restriction offered by the temporo-mandibular joint. One characteristic, however, of the occlusal position when the natural teeth remain is that the condyles occupy the most distal position in the glenoid fossæ which they can assume. This distal position of the condyles is one of the requirements for the occlusal position of the mandible for an edentulous case. It is only in such a position that the muscles can be free from strain and the jaw be in a state of equilibrium. This position of the condyles is the ultimate one reached by them from the various movements incident to mastication, and the artificial teeth must be arranged so that when the condyles reach this point the teeth will fit together in proper occlusal relationship.

With the condyles of the edentulous mandible in their most distal position in the glenoid fossæ, only the movement of its anterior end as it is raised or lowered by the muscles has to be reckoned with. This

simply means that it has to be established a certain distance from the upper jaw, and this distance is determined wholly by considerations relating to the appearance of the tissues of the face. This latter is the only available guide by which the position of the mandible can be fixed, and it must be such that the contours and proportions of the face are harmoniously arranged. Were it possible to keep the condyles in the back part of their fossæ at all times during the determination of the position of its anterior end, it would be simple enough to secure a satisfactory occlusal position for the mandible. It would then be only necessary to hold the jaws apart the amount dictated by a correct judgment of the case in hand when the occlusal position would have been found. But as will be seen later, it is very difficult to get and to keep the condyles back in their fossæ during such manipulations, so it is necessary to solve the problem by a different method. This consists in providing a means of maintaining the jaws a certain distance apart (already ascertained as proper for the case in hand) and then to induce the condyles to slide back to their most distal position. This is the rationale of all proper bite-taking methods.

In securing this relation it is necessary to make use of plates which fit the jaws, and, by affording mutual bearing surfaces, provide a means of keeping them a definite distance apart. If these plates are fixed together while the jaws are in the occlusal position, they thus make a record of it, so that the casts may be mounted in the articulator in accordance therewith. They serve also as a means of recording the other data mentioned above, and as a guide in mounting the teeth. They are called "bite-plates."

BITE-PLATES.

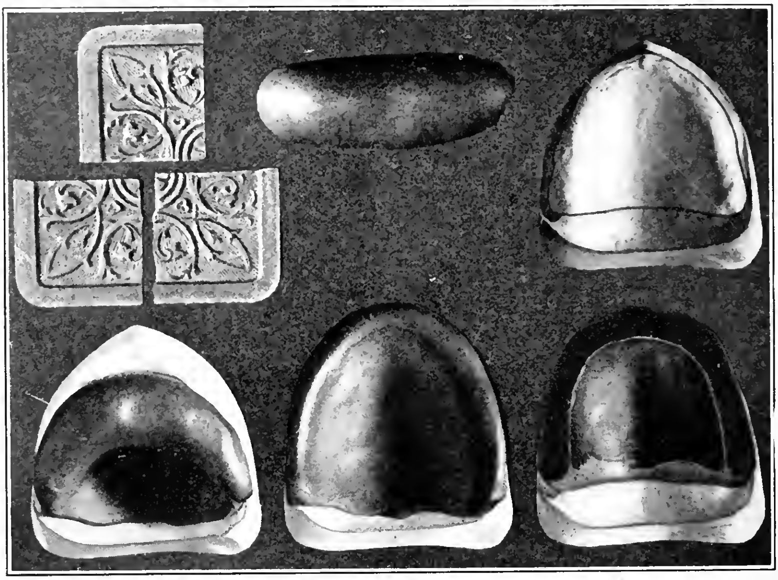
By reason of the temporary nature of its service it is desirable that the bite-plate should be made of a material which will admit of being molded into requisite form over the cast and without injury to it. Sufficient rigidity at the temperature of the mouth to insure the firm retention of the bite-plate, and sufficient hardness to prevent change in its shape while in use, are qualities which it must possess. Because of the fact that its original form is wholly tentative, as the plate must be trimmed or enlarged to meet indications when the bite is taken, the material should also readily allow these changes. Wax and its various combinations, as pink paraffin and wax, white wax, etc., are the substances in most common use for this purpose, but they are open to the objection that they are not hard enough, nor are they sufficiently rigid at body temperature unless used in such amounts as to make the plates unwieldly. Gutta percha and wax,[1] ideal base plate,[2] and other materials of greater stiffness have been used. Of the molded materials, modelling compound seems to possess the largest number of qualities to recommend it, while objections to it may be overcome by attention to the details of its use, as will be seen later. Because of their rigidity, bite-plates swaged of vacuum-chamber metal[3] and other soft

[1] Evans. [2] Head. [3] Essig.

metals have been used, the occlusal portion of the plate being made of one of the heat-softened materials. The amount of time necessary to execute the various steps in the making of swaged bite-plates for dentures to be made of one of the molded bases is so serious a drawback to the method that in most instances it is impracticable, but their advantages should not be forgotten in dealing with difficult cases.

For the Upper Jaw.—To construct a bite-plate of modelling compound for the upper jaw, the cast should be placed upon its base on the work bench with the distal portion toward the operator. (Fig. 309.) The plate outline should have been marked upon it, but the placing of the vacuum-chamber form, and any alteration of the face of the cast by additions of tin-foil for retention purposes, should be

Fig. 309



Steps in the formation of a bite-plate for a full upper case.

deferred until a subsequent time, because they would probably be disturbed in the forming of the bite-plate. The method of making the bite-plate in one piece proposed by Dr. W. W. Evans[1] is to be recommended. Three-fourths of a cake of modelling compound is softened in warm water, kneaded in the hands until homogeneous, and rolled into an ellipsoid about two inches long. One side of this should be thinned out by pressure between the fingers, and the mass so placed upon the cast that the thinned portion projects slightly beyond the posterior margin of the plate outline. By manipulation with the thumbs the remainder of the compound is gradually worked forward so that the vault of the cast is covered by it to the thickness of about $\frac{3}{32}$ of an inch. The thickness of this may be readily gauged, for the cast chills the material as it comes

[1] International Dental Journal., vol. xx., p. 221.

in contact with it, thus hardening it, while the overlying soft portion may be pushed forward. When the top of the alveolar ridge has been reached, the compound should be carried over it and slightly beyond the plate outline, along the labial and buccal surfaces, the most of the mass, however, remaining upon the ridge and being shaped to represent the occlusal portion of the bite-plate. The probable relation of this part of the artificial denture to the alveolar ridge and the probable fulness of the buccal and labial portions should be borne in mind and the compound disposed accordingly, since the bite-plate when completed should be a rough model for the denture in these particulars. It should be taken from the cast, chilled in cold water, and trimmed around its periphery to the plate outline. It ought then to be replaced upon the cast and its margin brought into close contact therewith, around the plate outline. This is to insure firm retention of the plate in the mouth, which is of the greatest importance, and should be secured, even if it be necessary to make at this time the changes in the surface of the cast which provide for the adhesion of the future denture. The form of the bite-plate at this time is largely tentative, as it is purposed to complete its modelling when the bite is taken, in accordance with the requirements which shall then be indicated. During the process of forming the plate, to prevent adhesion, the hands should be wet and the compound occasionally taken off the cast to break up its adhesion while it is soft, and then replaced, but under no circumstances must the cast be wet, as this will injure it for subsequent use. Rubbing its surface with soapstone or talcum powder will effectually prevent the adhesion of the compound.

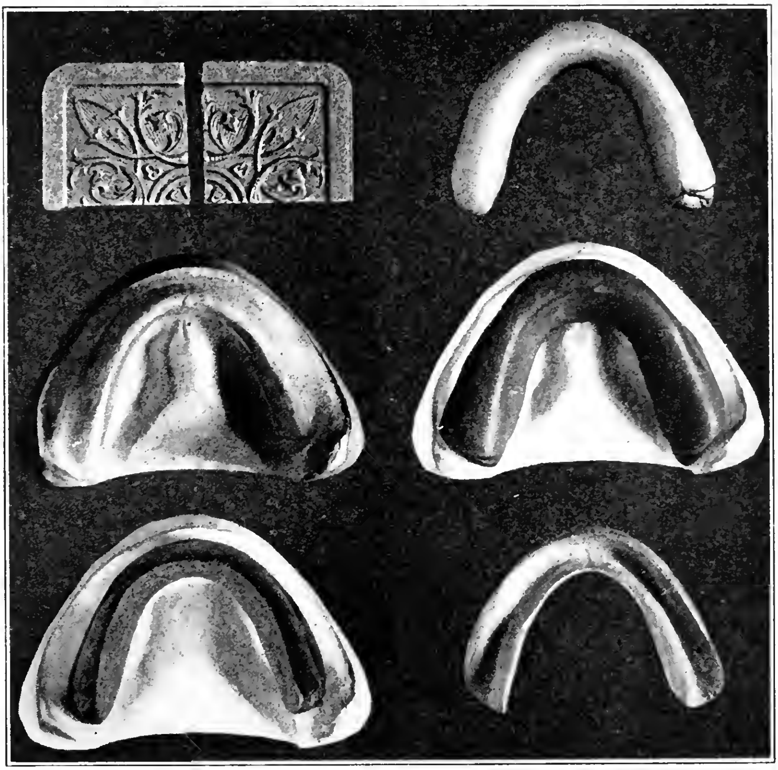
It is possible to construct the plate in two portions, that in contact with the mucous membrane being made of one piece of modelling compound rolled into a thin sheet and adapted to the cast, that representing the occlusal portion being formed of a roll bent to the shape of the alveolar ridge, and made to adhere by dry heat. The occlusal portion is made of wax by some practitioners because of the greater ease with which it may be carved, but its softness and tendency to yield under pressure make it less safe than modelling compound in preserving a fixed distance between the jaws.

The Lower Bite-plate.—The lower bite-plate is more easily made than the upper. With the cast face up on the work-bench, a piece of compound equal to about one-half of a sheet is softened and worked into a long uniform roll, bent to the shape of the alveolar process, and placed upon its summit. (Fig. 310.) With the thumbs and fingers it is worked down the lingual and labial sides to a point slightly beyond the plate outline, that portion over the ridge being shaped to represent this part of the future lower plate and made to correspond in outline to the arch of the upper bite-plate. It is removed and trimmed to the plate outline like the upper, its occlusal surface being left rough. If the lower plate must be very thin, it may be strengthened by imbedding in it a piece of iron or brass wire shaped to conform to the alveolar outline.

In taking the bite for a swaged or cast metal plate, for a continuous-gum denture, or for a vulcanite plate where the base-plate has been previously vulcanized, the base-plate itself is used for the bite-plate with an addition of modelling compound over the alveolar ridge to give it an occlusal surface.

Technique of the Operation.—The securing of the relation between the jaws may be divided into two stages—the fitting and shaping of the bite-plates, and the use of them in securing the relation of the jaws in the position of occlusion.

Fig. 310



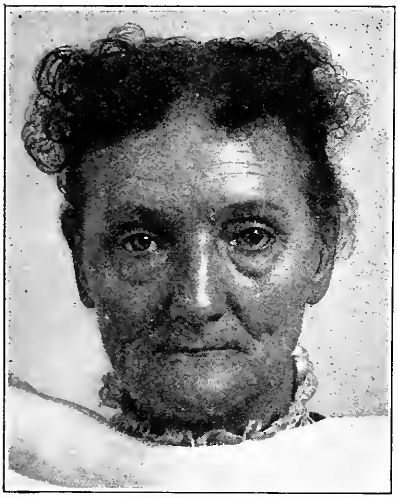
Steps in the formation of a bite-plate for a full lower case.

The patient should be seated in an erect position in the dental chair. (Figs. 311, 312.) The upper bite-plate is first tried in and the plate outline followed by it verified or corrected if necessary. It is essential to the success of the operation that the bite-plate should remain firmly in position and it should be trimmed where any movable tissues tend to displace it. Its adhesion may be improved by scraping from the centre of the palatal side to relieve pressure at this point and by accentuating the contact of its periphery by bending. It should then be observed whether the buccal and labial portions of the plate restore the contours of the lip and cheek tissues which they support, in accordance with prin-

ciples contained in Chapter XII., and the plate added to or trimmed as may be indicated. While the modelling in these regions cannot be completed at this stage, it is advisable to have the form answer the requirements of contour as fully as may be possible. The inclination of the occlusal portion of the plate to the ridge may be changed by reheating in water and bending after replacing it upon the cast, but additions of compound to the plate should be made to adhere by means of dry heat applied to the two surfaces, by which means its adhesive property is best developed. Any trimming may be easily done while the material is slightly warm, as it may be cut with a knife without dragging at this stage, and as it becomes brittle and hard when cold.

A most important point of reference which will be utilized in the construction of the denture and which determines the length of the occlusal

Fig. 311



Patient with edentulous jaws. Front view. Preparatory to taking the bite.

Fig. 312

Patient with edentulous jaws. Profile view. Preparatory to taking the bite.

portion of the bite-plate is now noted. This is the lower margin of the upper lip when in repose. This should be marked upon the labial surface, and the occlusal portion of the plate trimmed to within one-sixteenth of an inch of this, so that the plate will project that amount below the lip.[1] (Fig. 313.) The anterior portion of the bite-plate should not be trimmed or added to in subsequent fitting together of the two plates, as the lower margin of this surface is to indicate the position of the incisive edges of the anterior teeth of the artificial denture. The distal portions of the occlusal surface should be trimmed to curve upward in accordance with the probable plane of occlusion of the future denture.

The lower bite-plate is now tried separately in the mouth, the plate outline verified, and then the two are put in together. The length of

[1] Dr. A. D. Gritman.

the upper bite-plate having been definitely fixed, it is purposed to trim the lower one so that when in occlusion with the upper, when the condyles are in the most distal part of the glenoid fossæ, the jaws will be held apart the distance it has been decided is proper for them.

If it were possible to ascertain what the occlusal position of the mandible was when the natural teeth were in place, it is probable that this would fulfil the requirements of occlusion for the artificial dentures in a majority of cases, although when the teeth have been out some time the tissues of the lips and cheeks have contracted and accommodated themselves to a lessened distance between the jaws. It will be necessary to determine this distance by a judgment based upon the external appearance of the face and particularly that of the mouth, and as this is affected by the fulness of the bite-plates as well as by their length, these two dimensions should be considered conjointly.

Fig. 313

Patient with full upper bite-plate trimmed to one-sixteenth inch below the upper lip.

The tentative form of the upper bite-plate is sufficient guide in the matter of contour to begin with, so the lower plate is trimmed to what is judged to be its proper length, and the contours readjusted subsequently if necessary, or if later alteration of the buccal or labial surfaces should show that the bite-plates are too short, they must receive additions to meet the indications. In judging of the final contours, three places require especial attention. (1) The lips need to be supported at their point of contact, as the margins fall in when the teeth have been lost. This is provided for by the amount of projection of the bite-plate at the point corresponding to the edges of the upper incisors, and by the inclination of its labial surface. (2) As a great deal of resorption has taken place at the site of the canine tooth, this area should be held out by the bite-plate, and the corner of the mouth given proper fulness. The upper bite-plate must be fuller and higher here than anywhere else.

(3) The other place at which fulness is often required is at the site of the bicuspids and first molars, where the cheek may be sunken in.

When the labial surfaces of the bite-plates have been built out to proper proportions, the distance between the nose and chin should be such that the lips just come in contact. (Fig. 314.) When the proper position has been obtained an equal amount of the mucous surface of both lips is displayed, the upper lip is inclined outward slightly from its base, and the lower lip is sufficiently everted to bring out the graceful curve between it and the chin. (Fig. 315.) If the bite is too long the lips will be strained in trying to cover the plates, or if too short, they will appear compressed or curled upon themselves. Where the teeth have been out a long time and where the tissues have wrinkled in consequence, it is impossible to take out all the wrinkles or to establish the ideal contour and proportions above suggested; and this is also true, of course,

Fig. 314

Patient with full upper and lower bite-plates in place. Front view.

Fig. 315

Patient with full upper and lower bite-plates in place. Profile view.

where they were not originally possessed. It should be remembered that during the fitting and trimming of the plates the condyles of the lower jaw must be kept in their most distal position. When they have once been secured in this position, the lower bite-plate should have its labial surface marked and trimmed or built out until it is flush with that of the upper bite-plate. During subsequent manipulations the relationship of these labial surfaces is a guide as to whether or not the condyles are in their correct distal position. In some cases patients have contracted the habit of protruding one condyle, thus throwing the lower bite-plate to one side. In such instances it will be found advantageous to mark the median line of the face upon upper and lower bite-plates at this juncture, being certain that both condyles are retruded at the time. During subsequent procedures lack of correspondence in these two lines will at once indicate a protrusion of one condyle.

The lower bite-plate must be trimmed to occlude evenly with the upper throughout its whole extent, and when the mouth is closed the contact between the two should be equal at all points. It is important that the bite-plates should be evenly trimmed, since there is danger that they may be in contact anteriorly and appear to be posteriorly, when they are really too short, and have been forced off the ridge by leverage on their anterior portions, and it is wise to leave the lower bite-plate longer behind than in front and trim it to accord therewith. When the plates have been fitted by trimming as closely as possible, an absolute fit may be obtained by removing the lower bite-plate and very slightly softening its occlusal surface over an open flame, quickly returning it to the mouth, and having the patient close in the occlusal position, gently pressing the plates together. It is important that in

Fig. 316

Patient with bite-plates of correct fulness, but too short.

Fig. 317

Patient with bite-plates of correct length not full enough.

this procedure the upper bite-plate be kept cool enough not to have its form altered at all. The final fitting may be conveniently judged by placing the index-finger of each hand in the mouth in contact with the buccal surfaces of the two plates, which serves to hold them on the alveolar ridges, and by pressing the ball of the finger slightly between the occlusal surfaces of the plates as the patient is directed to close the mouth slowly, they are held apart at places where they do not fit properly. These occlusal portions afford rigid and unyielding surfaces that maintain the jaws apart the distance which has been decided upon. The bite-plates so fitted should now be removed from the mouth. Their occlusal portions should be trimmed down from the inside until they are not more than three-eighths of an inch wide. This is to give room to the tongue and to make them as comfortable as possible for the patient. It may be stated that the more nearly they approx-

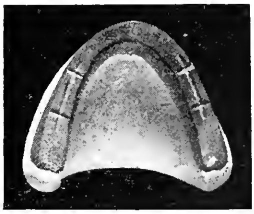
imate the future denture in form and size, the greater will be the likelihood of accuracy in taking the bite. They should have grooves cut upon their occlusal surfaces, as illustrated in Figs. 318 and 319, transverse ones at the site of the first molar and first bicuspid teeth, and a longitudinal one between. The grooves receive the wax to be used later in fixing the plates together.

Having thus determined by means of the rigid occluding surfaces of the bite-plates what the distance between the jaws shall be, the second stage consists in securing the mandible in such position that the plates are in contact and the condyles are back in the glenoid fossæ, and the position of occlusion is obtained. If the bite-plates are then fixed together and taken from the mouth, the casts may be placed in position in them and mounted upon the articulator. The

Fig. 318

Full upper bite-plate, with yellow wax on occlusal surface.

Fig. 319



Full lower bite-plate, showing grooves cut on occlusal surface.

difficulty which presents itself in this procedure is in getting the condyles back in the fossæ.

When the natural teeth are in the mouth consciousness of the occlusal relation is derived from sensations transmitted through the teeth, which are sensitive tactile organs and give instant knowledge of the position of the mandible whenever they are in contact. Absence of muscular strain and absence of a strained feeling at the joint also contribute to a knowledge of this occlusal relation, but the muscular apparatus itself does not possess a sufficiently accurate muscle sense to convey this information. If the mandible is not forward of the incisive relation the inclined planes of the cusps of the teeth form guides, which serve to insure its return to the occlusal position when the elevators are contracted. At the posterior end of the mandible the fossæ present inclined surfaces which serve as guides to the condyles in their return to the distal position occupied by them during occlusion. With the teeth missing we have only the temporo-mandibular joints as guides in directing the mandible back to the occlusal position. A further consideration of this joint will serve to give a clearer understanding of the problem under discussion.

The temporo-mandibular articulation is a condyl-arthrodial joint. Into the glenoid fossa, which at its posterior extremity presents a

marked concavity, fits the condyle of the lower jaw, with the interarticular fibro-cartilage interposed between them. The condyle is attached to the rim of the fossa by means of the capsular ligament, to the centre of which latter the cartilage is attached. The ligament thus binds the condyle in its fossa and imposes certain limitations upon its movement. The anterior portion of the fossa presents a flat articular surface over which the condyle and cartilage may glide in the various movements of the mandible. During the protrusive movements of the jaw this arrangement permits the condyle to slide forward upon the floor of the glenoid fossa, in which movement it is accompanied by the cartilage. At any time during this forward movement the mandible may rotate about a horizontal axis, passing through the condyles as they rest on the cartilages, and a combination of these two movements frequently takes place. These movements may be bilaterally symmetrical or there may be movements of one condyle forward and inward, the other remaining in the distal part of the fossa. When the mandible is depressed the condyles also slide forward in the glenoid fossa. This is due to several anatomical peculiarities of the joint as well as to the fact that external pterygoid muscles pull forward both the condyles and cartilages. The external and internal lateral ligaments are attached to the neck of the condyles and extend so far forward in their attachment to the rim of the fossæ that they serve as fulcrums to force the condyle forward during the depression of the mandible.

In returning to the position of occlusion from any of these excursions it is by retraction and elevation or some combination of these movements according to the position from which the return is made. Normally this is accomplished by the contraction of the masseter, temporal, and internal pterygoid muscles, sometimes in combination with the muscles attached to the anterior end of the mandible. By the contraction of the elevators the main body of the jaw is drawn upward and backward when the condyles slide up the inclines of the glenoid fossæ into their most distal parts. The lower fibres of the temporal muscle, the inner fibres of the internal pterygoid, and the posterior fibres of the masseter muscles serve to draw the jaw back, opposing the action of the external pterygoid, though not directly in line with it. For complete retraction to occur there must be total relaxation of the external pterygoid, as these muscles have the power of fixing the condyles at any point in their return path. If the condyles are thus fixed at any point before their most distal position is reached, the elevation of the mandible may continue by rotation about this now fixed axis. When the anterior end of the mandible is completely elevated it will then be forward of the occlusal relation, when, if the natural teeth are present, their contact serves to give information of the fact. But with the edentulous patient this source of knowledge is removed, and he is unable to assist in the operation of securing the proper occlusal relationship. Even though there is a complete understanding on the part of the patient as to what is required, he no longer possesses the means of judging if this is ob-

tained, and his efforts are not only not helpful, but often greatly hinder the work of the dentist.

After the loss of the teeth changes in the joint incident to this condition frequently further complicate the problem at hand. The elevator group of muscles, being no longer accommodated to a fixed position of the mandible, usually shorten, as do the other tissues extending between the jaws. The ligaments of the joints become stretched and the articulation becomes loose and wandering. The anterior portion of the glenoid fossa becomes absorbed, resulting in a flattening of its floor, all of which factors tend to make the protrusive movements easy and those of retraction uncertain. The longer the teeth have been absent, the greater will be the tendency toward protrusive movements. Lack of precision in the movement of the jaw will also frequently be increased by the various manipulations incident to fitting the bite-plates.

It becomes very difficult, therefore, to secure the jaw in its distal position. In this operation efforts are directed to compel the patient to close the mouth and bring the bite-plates together, and to have the jaw slide back to its proper position. Measures which are utilized to fix the plates together at the same time that the mouth is closed are open to the criticism that they serve to increase the protrusive tendency if much force has to be exerted in bringing the jaws together, and great care must be taken to avoid this error. It may be stated as a truism that the smaller the amount of force necessary to close the jaws, the less likelihood will there be of protrusion. Goslee[2] has called attention to the tendency to a continuation of the incising relation which may be caused by having too much wax upon the anterior part of the plates. This offers the same sort of resistance to the closure of the jaw as is met with in incising food, and the muscular movements which are useful in incision are reflexly provoked thereby. Instructing the patient "to bite" usually conveys the idea "to incise," that being the common meaning of the word, and the movements of that operation are suggested. It is safest to use the term "close the mouth" in giving directions during the procedure, as that more nearly than any other suggests the desired movement.

The operator must be able to tell when the jaw is in its posterior position, in which he may be assisted by palpation of the external end of the condyle, and by inspection of the surface of the skin during its motions, and by resorting to the measures which induce its backward movement. While it is there, the bite-plates must be marked and so trimmed that their anterior surfaces are flush, to serve during subsequent procedures as an indication as to whether the jaw is protruded. The median line may also to advantage be marked upon both plates so that a protrusion of one condyle would be noted. The plates should fit firmly, be comfortable and stable in position, and the patient should be engaged in conversation, and, if possible, made to forget the operation. Then they should be taken out, wiped dry with a napkin, and replaced.

[1] Transactions Odontological Society of Great Britain, 1900, p. 167.

[2] Taking the Bite. The Dental Review, vol. xvii., p. 509.

and a small quantity of very soft yellow wax placed over the grooves on each side of the upper plate. The patient is then directed to swallow, and, as the lower jaw has to be fixed for this operation to give a base from which the elevators of the larynx may work, the condyles are usually forced back in the fossæ. By this means the patient is engaged in the performance of an act which is naturally done when the condyles are back in their fossæ and the tendency to protrusion is thereby considerably reduced. It must be observed that the bite-plates have been brought into the proper relation, and also it must be assured that they are in position on the ridges. It may occasionally be necessary to hold them in position, especially in the case of a lower jaw in which there has been much absorption.

If the head is thrown backward the tissues of the front of the neck attached to the lower jaw, particularly the platysma myoides, are put on the stretch, the tendency being also to carry the jaw backward. Instructing the patient during closure of the mouth to touch the palatal vault with the tip of the tongue as far posteriorly as possible also, has the advantage of tending to keep the jaw far back. Asking the patient to bite the back teeth together may assist in securing this position, because of the fact that in the natural denture this is not possible when the jaw is protruded. Efforts to hold the jaw back by clasping the fingers behind the ligamentum nuchæ and pressing with the thumbs on the chin, or pushing it back forcibly by pressure on the chin during the closing, have been recommended and in some cases they may be successful, but frequently they are so resisted by the patient as not to be effective.

Fig. 320

Garretson's device for keeping the condyles in the distal part of the fossæ in taking the bite.

Dr. Molyneaux, in cases of extreme difficulty, recommends the use of Garretson's device as follows:

"A little apparatus, which was invented by Dr. Garretson, of Iowa, has been satisfactorily employed in several cases, and is illustrated in Fig. 320.

"It consists of two steel strips about 6 inches long, at one end of which are projections to enter the external ear, and a leather strap passing over the occiput which prevents the ear pieces from slipping down. At the other ends of the metal strips is a chin plate which works on a ratchet, and which may be moved forward or backward as the case requires. After placing the ear pieces in position and tightening the straps, the chin plate is to be moved up firmly against the chin. The patient should now open and close the mouth repeatedly, and as the lower jaw is drawn backward the chin plate is moved upward until it is certain that the condyles are at rest in the glenoid fossæ. In this position the patient can open and close the mouth comfortably, but any attempt at protrusion will meet with resistance by the ear-lugs.

"The base plates are then adjusted and the bite is taken as usual."

The wax interposed between the two plates should be small in amount and quite soft. It serves two purposes—to unite the bite-plates in the position of occlusion and to compensate for any failure of their occlusal surfaces to be in uniform contact. It is difficult in trimming an unyielding substance like modelling compound to get two surfaces to fit absolutely accurately, although, of course, this should be attempted. The wax at properly distributed points offers enough resistance to hold the plates in contact with the membrane, but not enough to interfere with the accuracy of closure. Care should be taken to see that the labial surfaces of the plates are flush, since by this means it may be seen that the jaw is in its most distal position. The bite plates may be fixed by fusing their edges together with a hot spatula, or by the use of staples of wire inserted on each side to bind them together, or in very difficult cases in which it is desired to interpose no resistance to the contact of the bite-plates, thin plaster of Paris may be used for the purpose as has been recommended by Ottolengui.[1]

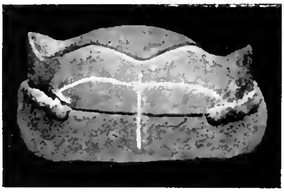
The High Lip Line.—In the usual movements of the lips in speaking the teeth are more or less exposed to view, and even greater displayal of the denture is made in laughing and smiling. The relation between the lips and the teeth in laughing and smiling has much to do with the beauty of these acts. It is usual, therefore, to take into account the amount of this exposure in the construction of artificial dentures, and the highest point to which the patient can elevate the upper lip should be indicated by a line drawn upon the upper bite-plate at the lower margin of the upper lip. This lip is more mobile than the lower, because a larger number of muscles move it, and more of the upper teeth are displayed in smiling and laughing. In separating the jaws the lower teeth are depressed below the margin of the lower lip, and it is usual to disregard this record on the lower bite-plate for the additional reason that the upper having been determined, the proportions of the lower are more or less harmonious therewith. It may, however, be marked upon the lower bite-plate and is then "the low lip line."

The Median Line of the Mouth.—This should always be recorded, for in a normal natural denture the line between the central incisors practically coincides with the median line of the mouth. The median line of the mouth is more or less difficult to determine for lack of an accurate guide in judging it. The frænum of the upper lip is usually in the median line, but it is by no means a safe landmark, for in a good number of cases it is a little to one side or the other. The median line of the cast and the little tip on the front of an edentulous upper cast, representing the incisive pad of the rugæ, are also unreliable; because the cast is frequently unsymmetrical from the fact that the teeth on one side may have been lost earlier and the resorption taken place to a greater extent than on the other side. The median line of the mouth must, therefore, be secured by data obtained from the face. The tip of the nose is so frequently out of the median line that it should not be used. The philtrum, when not obliterated, is a safe point of reference. The

[1] The Dental Cosmos, vol. xliv., p. 446.

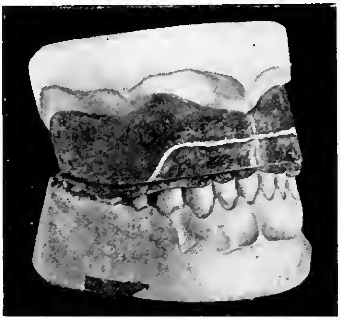
base of the septum of the nose and the median line of the chin may also be used. The mouth itself is sometimes from habit or otherwise one sided, and then the line fixed upon as the median line should occupy a position between the median line of the mouth and that of the face. After it has been determined upon, it should be marked upon both bite-plates perpendicular to their line of division while they are still

Fig. 321



Upper and lower bite-plates fixed together with wax and showing high lip line and median line of the mouth.

Fig. 322



Bite-plate for full upper denture in case in which the lower natural teeth remain. Cast set in bite-plate preparatory to mounting in articulator.

in the mouth. Fig. 321 shows the bite-plates removed from the mouth and exhibits the median and high lip lines.

BITES FOR FULL UPPER OR LOWER PLATES.

The bite for a full upper plate where the lower natural teeth remain in whole or in great part, involves the construction of a bite-plate in accordance with principles already outlined. It should be tried in the mouth, trimmed tentatively for contour and length to the lower margin of the upper lip, and the patient requested to close the lower teeth upon it. Special care should be taken to see that the lower teeth strike evenly upon its occlusal surface, and, when the jaws are closed in the position of occlusion, the lips and cheeks should be lifted so that it may be seen whether this is the case, and an excavator should be used to try to pry the jaws apart at each tooth to prove the contact. The external contour and distance between the jaws should be established in accordance with the principles which underly their determination in full upper and lower cases. After the plate has been satisfactorily shaped to fulfil these requirements, it is removed from the mouth, wiped dry with a napkin, and the occlusal surface covered with a thin layer of very soft yellow wax, which should be made to adhere closely, and only thick enough to receive indentations of the occlusal surfaces of the lower teeth. It is replaced and the mouth closed as in the previously described bite-taking operations. The patient should bite

into the wax until the cusps of the teeth touch the bite-plate, which insures that the distance between the jaws is the same as was determined by the bite-plate. It is important that only a small amount of wax be used because of the increased tendency to protrusion caused by too great a quantity. The bite-plate may be marked with a line to note the position between the lower central incisors to assist in bringing the lower jaw to a correct position, and the relation of the incisors to the edge of the bite-plate will also assist in this purpose.

The high lip line and median line of the mouth should be marked upon the bite-plate, since the line between the lower central incisors is too frequently out of centre to be depended upon for setting up the teeth, and the median line of the mouth is a safer guide. The bite-plate should be removed from the mouth, the wax chilled in water and laid aside, and an impression taken of the lower jaw, a cast made and fitted into the depressions in the wax of the bite-plate. (Fig. 322.)

Bites for Full Lower Plates.—In taking the bite for a full lower denture, a bite-plate must be made for the lower jaw as described earlier in this chapter. It rarely occurs that the upper natural teeth remain in a mouth in which all the lower have been lost, and the common case requiring a full lower denture is that in which there is already a satisfactory upper. The general procedure is the same with either artificial or natural upper teeth. The lower bite-plate is formed and trimmed to occlude evenly with the upper teeth, and of such length that the distance between the jaws as determined by the appearance of the patient is correct. The bite-plate is given a layer of wax over its occlusal surface and the bite taken in the usual way. Where there is an artificial denture for the upper jaw, it is well to remove this with the bite, to mount it upon the articulator, and to articulate the lower teeth to it rather than to a cast formed from the tooth depressions in the wax. Where the denture has been made some time before the lower teeth were lost, and particularly where the teeth are set at irregular levels to occlude with the natural ones, it is advisable to reset them with the lower teeth, as a much more satisfactory occlusion may be obtained.

Bite-plates for Temporary Dentures.—These differ in no wise from the plates already described, except that they do not extend over the labial surface of the cast, this being more especially true of those for the upper jaw. This arrangement is, of course, necessitated by considerations of contour. They are, in consequence, more difficult of retention, and this must be looked out for and provided for by means already discussed.

Bite-plates for Partial Dentures.—Except in those cases in which only a few teeth have been lost, bite-plates must be constructed for taking the bite for partial dentures. In general it is better to construct them of a thin sheet of modelling compound rolled out to about the thickness of No. 12 gauge, adapted to the cast, and trimmed to the plate outline. Vacancies between the teeth are built up with additions of modelling compound to the level of the adjacent teeth at such places as it is necessary that the plate should oppose a tooth in the opposite jaw

and stay the bite. (Figs. 323 and 324.) Where the natural teeth remaining occlude and stop the closure at that point, these spaces on the partial bite-plate may be built up with soft wax just before the closure for fixing the bite is made, the soft wax receiving an impression of the opposite teeth.

Partial bite-plates may often be strengthened to advantage by imbedding iron or brass wire of proper shape in them at such places as will be exposed to strain, and this is particularly true of partial lower plates.

Taking the Bite in Partial Cases.—(1) In the construction of dentures for partial cases where the remaining natural teeth occlude prop-

Fig. 323

Bite-plate for partial lower denture.

Fig. 324

Bite-plate for partial upper denture.

erly and particularly if only a few have been lost, it is only necessary to be assured that the teeth of the casts occlude in the same way that the natural teeth do, and, if there are enough points of bearing, occasionally they may be mounted on the articulator without taking the bite. If, however, a roll of soft yellow wax is placed between the patient's teeth and they are brought to the position of natural occlusion, the wax may be pressed up with the fingers, cooled with water, removed from the mouth, and the casts may be fitted into the wax with the assurance that their relation is correct. It is important to be certain that the teeth come into the position of correct occlusion when the jaws are closed upon the wax, and it is expedient to mark opposite points with a lead pencil upon the external surface of two teeth that occlude, and to observe if these bear the same relation when the jaws are closed for the bite. This includes partial upper or partial lower dentures or both.

(2). Where the teeth remaining do not occlude, as in the case of a partial upper and partial lower denture, it is, of course, necessary to have bite-plates to establish the distance between the jaws, as was done with the full upper and lower. These are trimmed tentatively to correspond in the length of their occluding portions with the adjacent teeth and are tried in the mouth. The same general principles which determine the length of the full upper and lower bite-plates must be borne in mind,

but the length of the remaining natural teeth will be the main guide in determining the trimming. The plates and teeth should occlude with the same evenness and firmness which is demanded of the full plates, each tooth striking upon the bite-plate. The plates are removed, wiped dry, and their occlusal surfaces covered with softened wax, and the bite taken as has been before described. With a full denture for one jaw and partial for the other, as in a case in which some of the lower natural teeth remain, the obvious method is to combine the principles of bite taking for partial and for full dentures, being guided by the natural teeth as to the length of the bite-plate, by the external appearance of the patient as to the contour and the distance between the jaws.

(3). There are occasional cases requiring partial upper or lower dentures or both where the remaining natural teeth occlude, but where they are either much abraded or have been driven out of their places by the force of occlusion, and the distance between the jaws which they establish is insufficient. It is usually advisable in such instances to "open the bite." The bite-plates are trimmed to a length in accordance with the amount it has been determined the jaws are to be separated, and the procedure is the same as where there were no points of occlusion. It must be borne in mind that the natural teeth separated by this measure should be built up by operative measures or by crowning, if possible, as they cannot otherwise participate in the masticatory functions of the denture. Instances demanding this proceedure are not of frequent occurrence, but a few cases are much simplified and the mouths much improved by thus establishing a new position of occlusion.

The determination of the relation of the jaws to the temporo-maxillary articulations, and the determination of the path of the condyle in its forward and lateral excursions are questions so closely related to the subject of articulators that it will be necessary to consider them conjointly.

ARTICULATORS.

As originally designed the instrument known as the articulator was simply intended as a means of maintaining the plaster casts in the position of occlusion during the operation of arranging and mounting the artificial teeth. The bite having been taken, the casts were arranged in the occlusal position and attached to the metal frames of the instrument, and thus their occlusal relation was preserved while the teeth were being set. In its simplest form the instrument consists of two frames joined by a hinge, which permits the separation of the casts without detaching them from the articulator. The invention of the device is attributed to J. B. Gariot about 1805.[1] Many forms of articulators constructed upon a similar principle have been used since that time, a common type in use at the present day being illustrated in Fig. 325.

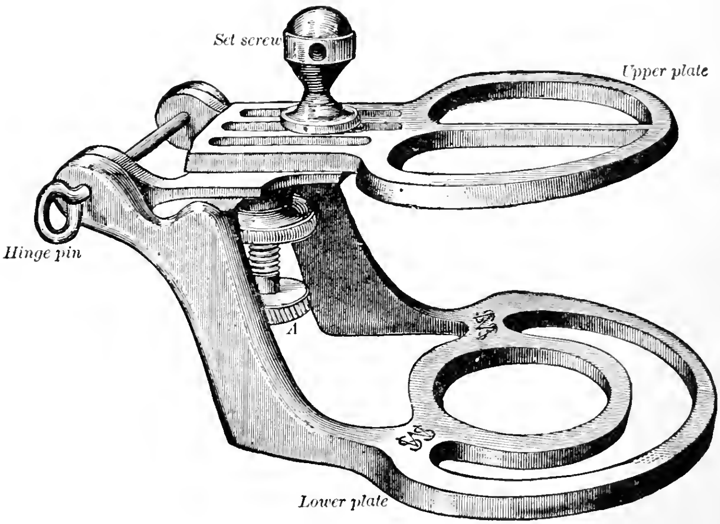
Except for convenience in handling while the teeth are being mounted,

[1] Guerini: The Historical Development of Dental Art. The Dental Cosmos, vol. xliii., p. 8.

the occlusal relations of the casts may be preserved in as satisfactory a manner by an extension of their posterior portions with plaster to form a point of bearing between them. An extension of one of the casts is made with plaster, the upper surface being made flat and having several well-defined depressions without undercut made in it, and it is then varnished. The other cast having been placed in the proper relation, its distal surface is similarly extended, the added plaster flowing over the varnished surface and establishing a bearing between them.

The hinge articulator is not intended as a means of imitating the masticatory movements of the jaw. As a rule, no attention is paid in mounting the casts upon it to see that they are related to the hinge joint as the jaws are to the temporo-mandibular articulation, nor, indeed, does the former resemble the mechanism of the latter in any way.

FIG. 325



Plain line articulator.

The mandible moves approximately in the arc of a circle in its depression and elevation (see Chapter IV.), but the centre about which this occurs is not in the condyle except at the beginning of the depression, and no simple hinge could imitate it. The casts mounted upon a simple hinge articulator, therefore, occupy the positions occupied by the jaws only when the casts are in the occlusal relation, and the joint of the articulator serves solely for convenience in separating the casts.

This form of articulator has a distinct field of usefulness, but its boundaries are prescribed. In those cases in which a number of the natural teeth remain in the mouth, as in partial dentures, or full upper or lower, where most of the opposing series are natural teeth, this instrument may be used with satisfaction. In these several instances the forms of the morsal surfaces of the artificial teeth are determined by those of their opponents of the natural series, which latter serve as a

safe index of the forms best adapted for masticatory purposes for the cases in question.

No type of this articulator should be used which is not sufficiently accurately made to avoid lateral movement at the joint. This mechanical defect may alter the relation of the casts in the occlusal position and the dentures will be correspondingly inaccurate. It must also be noted that the frequent practice of attempting to correct defects in the vertical relations of the casts originating from an inaccurate bite, by raising or lowering the upper portion of the articulator, as the bite is found to be too short or too long, is to be decried because the relation thus established between the casts cannot be that ever existing between the jaws.

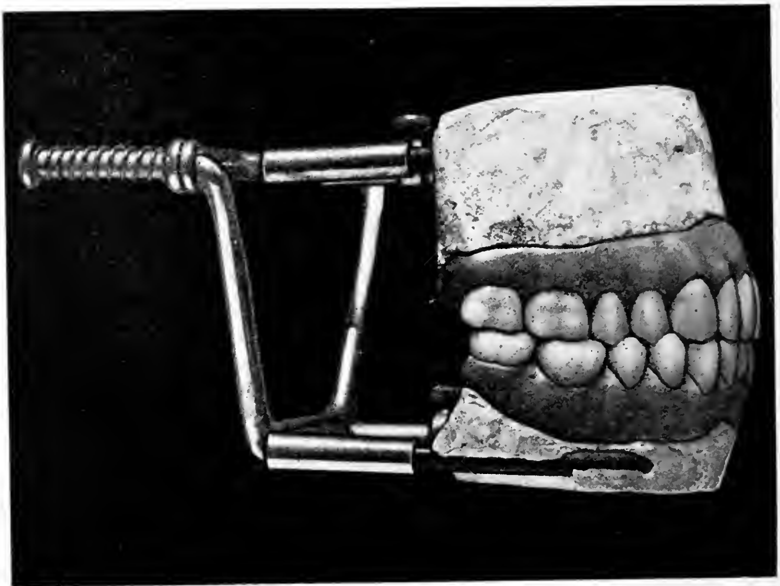
In the use of this instrument the casts are placed in their proper positions in the bite-plates, having been trimmed so that they may be accommodated between the jaws of the articulator. As they are to be attached by means of plaster, and, as after this has set and dried out it becomes so hard that there is danger of fracture to the casts when they are removed, it is advisable to coat the bases of the casts with sandarac varnish, with the exception of a small area about the size of a twenty-five-cent piece in the centre of this surface. The casts are wet and a plaster batter used to attach them to the articulator, the union obtained from the small unvarnished area being sufficient to hold them in place, and yet they may be removed without difficulty after the teeth are set up.

The first instrument in which an attempt was made to imitate the temporo-mandibular joint with the joint mechanism of the articulator and thus to permit a reproduction of the masticatory movements of the mandible was that of W. G. A. Bonwill. It was designed by him in 1858, and its well-known form is shown in Fig. 326. With this apparatus an effort was made to imitate the movements of the mandible occurring in its forward and lateral excursion, as well as in its depression. The joint mechanism consists of a ring sliding upon a bar, in imitation of the sliding movement of the condyle, the direction of the bar determining the path pursued by the lower cast. The ring is attached, however, to the portion of the articulator carrying the upper cast, the bar being a part of that carrying the lower. So long as the upper and lower loops of the instrument are parallel, the path of the condyle as represented by the bar is parallel to them, and hence in a horizontal direction; but as the portion carrying the lower cast is depressed, rotating about a horizontal axis passing through the rings, the bar, being a portion of this, is correspondingly elevated, its angle with the horizontal plane is changed, and the path of the condyle is represented as descending, the angle which it makes with the horizontal being determined by the amount of depression of the lower portion of the instrument. This is a faulty principle, and the instrument does not accurately represent the movement of the jaw. It was shown in Chapter IV. that the path of the condyle is downward and forward, that it is rarely horizontal, and although the paths differ in different individuals, an

instrument representing the condyle path by a bar, the inclination of which is changed as the jaw is depressed, cannot correctly imitate the mandibular movement.

The instrument represents the condyles as four inches from the centre of one to that of the other, and it is directed that the casts should be placed upon the articulator with their general alveolar planes parallel to the loops to which they are attached, the centre of the lower alveolar ridge in front being located four inches from each of the rings representing the condyles. This presupposes a uniform intercondylar distance of four inches, and a like distance between the centre of each condyle and the lower alveolar ridge, conditions which do not obtain in

Fig. 326



Bonwill articulator. (Photograph of instrument in collection of the Department of Dentistry, University of Pennsylvania.)

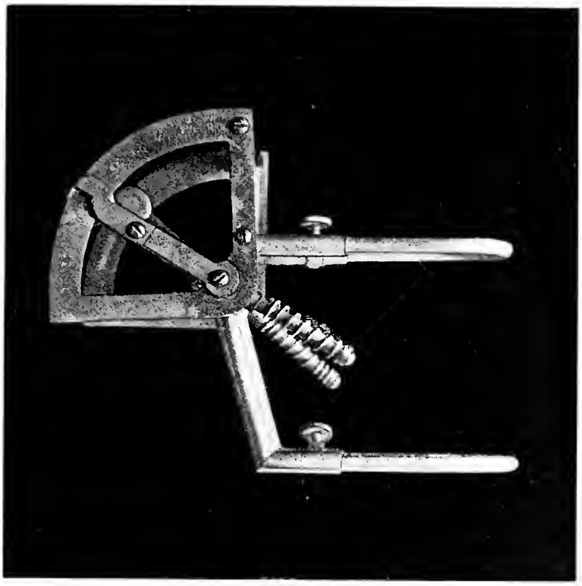
the natural jaw. Cryer[1] has called attention to the difference in intercondylar distance in two mandibles in his possession: furthermore, such uniformity in the dimensions of the jaws of different individuals is not in accord with actual anatomy. The instrument, besides being constructed upon a faulty principle, is not adjustable in any way to the individual case, and represents the ideal of the designer. The principles of tooth articulation, however, enunciated by Dr. Bonwill in connection with this articulator are extremely valuable, and will be discussed in a later chapter.

Various efforts have been made to reproduce the movements of the lower jaw by means of an instrument. The articulator designed by

[1] Internal Anatomy of the Face.

W. E. Walker,[1] illustrated in Fig. 327, was an improvement upon the Bonwill articulator, in that the bar determining the path of the condyle is adjustable to any angle. By means of a "facial clinometer," to be

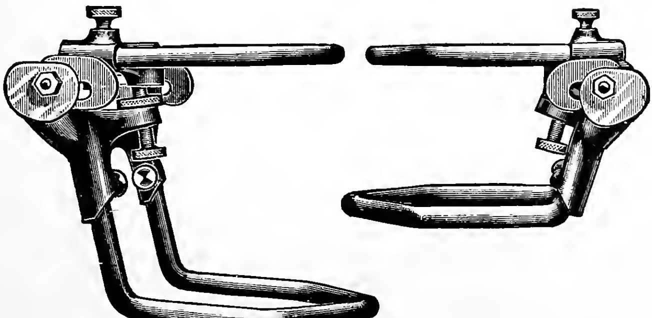
Fig. 327



Walker's articulator.

used in connection with the instrument, the angles made by the paths of the two condyles with the general alveolar plane are determined for each patient and the articulator is set to correspond therewith.

Fig. 328



The Gritman articulator.

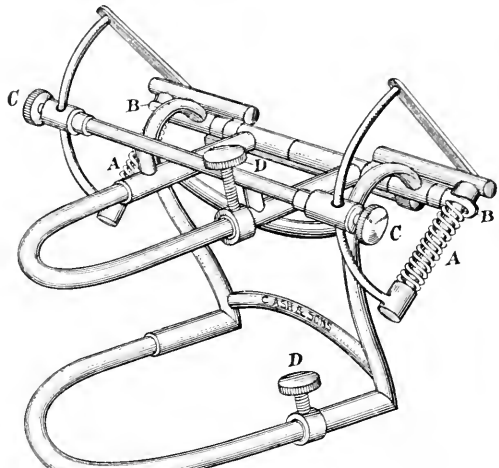
It is a somewhat complicated apparatus and has never come into general use.

The Gritman articulator[2] (Fig. 328) represents the path of the con-

[1] Facial line and angles in prosthetic dentistry. The Dental Cosmos, vol. xxxix., p. 789.
[2] Introduced in 1899.

dyle as a straight line making an angle with the general alveolar plane which the designer obtained as an average by the measurement of a large number of skulls. The superior mechanical construction and convenience of this instrument have recommended its use to many, but it is not capable of adjustment to the exact requirements of the

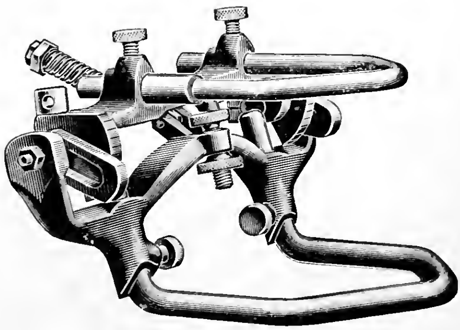
FIG. 329



Christensen's articulator.

individual case. The articulator of Christensen[1] (Fig. 329) is capable of adjustment in the matter of the direction of its condyle paths. The New Century articulator[2] (Fig. 330), designed by George B. Snow, has the mechanical excellence of the Gritman articulator and, in addition,

FIG. 330



New Century articulator, designed by George B. Snow.

has adjustable condyle paths. In common with all anatomical articulators so far described, it is constructed on a plan of a constant intercondylar distance of 4 inches and is not adjustable in this particular.

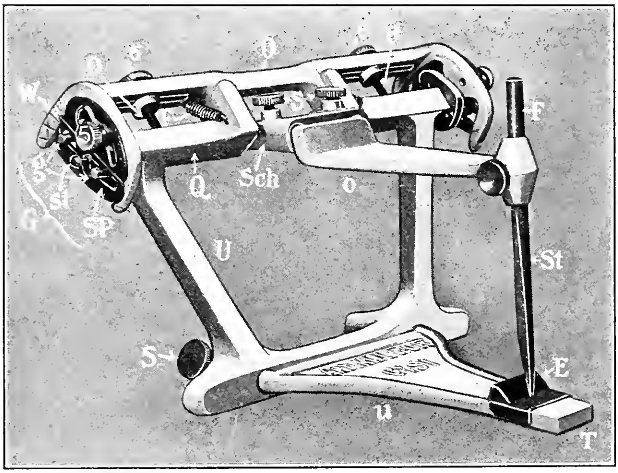
[1] Ash's Quarterly Circular, December, 1901, p. 409.

[2] Introduced in 1907.

For general use in the laboratory it will be found an instrument of sufficient precision for all practical purposes.

While the fact that the path of the condyle is not a straight line has been proved by the work of various investigators, notably J. B. Parfit,[1] George C. Campion,[2] Thos. E. Constant,[3] it has been represented as such in all the instruments so far discussed. The articulator of J. B. Parfit represents the path as curved, and pieces of metal plate, having been cut out to correspond with the ascertained paths of the case in hand, are clamped to the frame of his articulator. Inasmuch as the paths of movement of the condyle while the teeth are in contact are the only ones with which we are concerned in the articulation of artificial teeth, and as this contact is maintained only in the movement of the condyle from its most distal position to a point somewhat short of the summit of the eminentia articularis, during which time the condyle

Fig. 331



Articulator of Gysi.

moves nearly in a straight line, for most practical purposes in tooth articulation it may be represented as such in the articulator.

The articulator of Gysi (Fig. 331) is the most accurate device so far designed as a mechanical representation of the temporo-mandibular joint. The following is a description of the instrument:[4]

"This articulator (see Fig. 331), like all others, consists of a movable upper part (Fig. 331, O), and a fixed lower part, u. To the upper part the straight bow (Fig. 340, O), is attached and secured by screws, S. An extra bayonet-shaped bow (Fig. 331, o) can be inserted as in Fig. 331, o, or inverted to correspondingly suit the height of the plaster

[1] A new anatomical articulator. Transactions Odontological Society of Great Britain, 1903, p. 337.

[2] Method of recording graphically the movements of the mandibular condyles in the living subject, The Dental Digest, 1903, p. 841.

[3] The movements of the mandible: Brit. Jour. Dent. Science, 1901, p. 807.

[4] The Dental Cosmos, vol. lii., p. 148.

models. To the lower part a straight bow is attached and secured by screws, S. An extra bow can be attached having a base that is $1\frac{1}{2}$ cem. higher. With these four bows six different combinations can be effected to correspond to the height of the plaster models, thus saving much time in their preparation for the articulator. The bows should be oiled and pushed as far into the articulator as they will go, so that should it be necessary for any reason to remove them, together with the models from the articulator, they can be easily and accurately placed in their former positions.

"To the upper bow an adjustable supporting pin, St, is attached, which rests on the narrow end of the small plate, T, of the lower bow. On this narrow end of the lower bow is attached an inclined plane, E, on which the supporting pin moves upward in the side movements. The supporting pin should always rest at the foot of this inclined plane. This inclined plane forms the incisor guide, and serves on the articulator as a substitute for the overbite. Up to the present the artificial incisors, attached with wax to the trial plates, have taken the place of this incisor guide. This was a most uncertain guide, especially in warm weather. For practical reasons, which will not be further discussed, this inclined plane is attached to the lower part of the articulator instead of to the upper part, just as all articulators have a fixed lower and a movable upper part, entirely contrary to the natural relations, but, as is well known, answering the same purpose.

"As the supporting pin acts as a guide to the height of the bite, it is placed in front of the incisors, because it is only here that a true and secure support can be obtained. If this supporting pin interferes with the setting up of the incisors, it can be removed until the latter are placed in position.

"File-marks (Fig. 331, F) can be made on the supporting pin, so that there is at all times a guide to show that the height of the bite has not been changed in the setting up of the teeth.

"The placing of this supporting pin in front of the incisors offers the further advantage that the articulator is quite unobstructed at the back, so that the lingual surfaces of the teeth are clearly visible and can easily be reached with the fingers and wax spatula. This is important, in that it permits of the correct articulation of the lingual surfaces of the teeth.

"The most important function of this supporting pin and the inclined plane consists in the prevention of the wrong downward movement of the upper part of the articulator produced in all articulators up to this time when reproducing lateral movements.

"The upper bow, O, is connected with the upper part of the articulator by a hinge joint, so that in the setting up of the artificial teeth opening and closing movements can be made that are independent of the true joint movement: consequently the two condyle parts of the triangle can be combined exactly and precisely with the incisive part of the triangle in such a way that all unnatural movements are impossible. In this manner the downward movement of the mandible com-

bines with the forward movement in the direct forward and lateral movements. This combined movement, which has long been recognized, is for the first time accurately reproduced by the articulator. The importance of this fact is fully explained in another chapter.

"The upper and lower parts of the articulator are connected through the real joint, G, which permits of the lateral movements. Two springs, F, automatically bring the two parts back to their normal positions.

"The joint is formed by the fork (g) of the lower part of the articulator, the prongs of which pass through the E-shaped part of the upper half and receive the slotted plate, Sp. The fork (g) rotates, and with the slotted plate can be fixed by the screw (5) at an angle of from 0° to 50°.

"The two identical slots in the slotted plate which receive the prongs of the fork (g) correspond in form to the path which the condyles take in their movements during mastication.

"To be quite exact, a number of different forms of slotted plates should be kept. From my long experience, however, I have found that the two average forms are quite sufficient, and if the artificial teeth are placed in the exact position necessary to secure the full value of the gradations of these two condyle path forms, the result is most satisfactory. If a special form for every case is thought necessary, as advocated by Campion and Parfit, it can be easily and quickly sawed out of thin brass plate and placed on the articulator.

"The pin, *st*, found on the slotted plate, serves to bring the latter into its proper place, and should always be placed in the hole provided for it in the middle of the E-shaped joint.

"In order to change the slotted plate, the binding screw, 5, is first loosened, then the prongs of the fork *g* are turned to a vertical position, which will allow the plate to slide over the head of the binding screw. With the prongs in the same position another plate can be put on and fixed at the desired angle. This is accomplished by placing the index of the slotted plate at the required degree on the engraved scale, W, in the E-shaped joint.

"When making full upper and lower dentures without measuring the individual condyle paths, the index of the slotted plate should be placed at the average angle of 30°. It is not absolutely necessary to measure the condyle path for partial dentures. In such work the slotted plate can also be set at the average angle of 30°. In this way, in extreme cases there can only be a difference of 20° above or below this average slant, which is not much when we consider that in using a Bonwill articulator there can be a difference of 45°.

"The two small supporting pins, D D, at the back, with the large supporting pin, *St*, form a secure triangle which is not to be found in any other articulator. This, together with the solid cast pieces, prevents any looseness or any springiness, and thus insures the possibility of true and exact work.

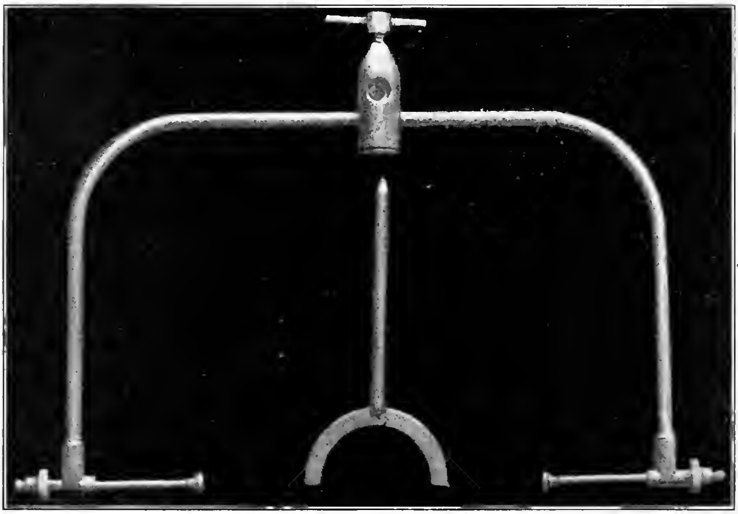
"The small supporting pins, D D, in the slotted upper part, *O*, can be moved sideways. They rest on the transverse piece of the lower

part, on which is an engraved scale to indicate the positions of the pins. As the positions of these supporting pins are determined by the incisor path, these scales are only of value when two or more full upper and lower dentures are to be made at the same time, when the different positions of these pins can be noted on the plaster models."

THE RELATION OF THE JAWS TO THE TEMPORO-MANDIBULAR ARTICULATION.

It must be evident that in an articulator in which the mandibular movements are to be imitated the casts must occupy the same position relative to the joint mechanism as the jaws occupy relative to the temporo-mandibular joint. Otherwise the joint mechanism would permit the casts to be moved relatively to each other in ways in which the jaws cannot be. A means of determining this with greater or less pre-

Fig. 332

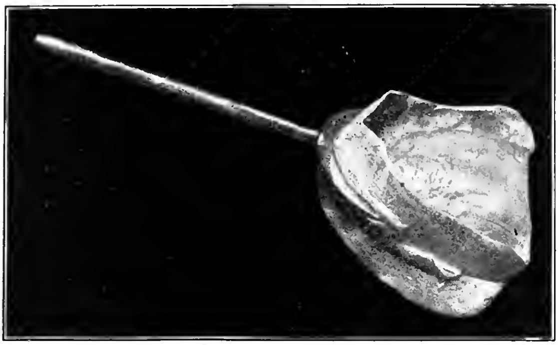


Snow face-bow, showing bow with projecting end pieces for placing over the condyles and clamp for attaching stem. Also stem with semicircular plate for imbedding in bite-plate.

cision is furnished in the Snow face-bow which is designed for use in conjunction with the Gritman articulator, but more recently with the New Century articulator. It is illustrated in Fig. 332 and consists of a stem with a semicircular plate attached for imbedding in the bite-plate, and a bow with a clamping device and projecting index rods at each end of the bow. The method of use of the appliance is as follows: After the bite has been taken and the bite-plates are firmly fixed together with the jaws in the occlusal relation, the plates are removed from the mouth, and the casts placed in them to prevent a distortion of their shape in subsequent manipulations. Then the semicircular plate of the stem is heated sufficiently to allow it to be imbedded

in the upper bite-plate (Fig. 333), the stem occupying the median plane of the plate. Care should be taken to see that the high lip line, the median line, and the lower edge of the bite-plate, which are to serve for reference in setting the teeth, are not disturbed by this procedure, and

Fig. 333



Stem with semicircular plate imbedded in upper bite-plate: ready to be returned to patient's mouth.

also that the plates themselves are not distorted in form or relation. The position of the external end of both condyles while the mandible is in its most distal position is then located by palpation and marked upon the skin of the face by a small piece of court plaster or a pencil mark. (Fig. 334.) It will be seen in Fig. 220, page 240, that the external end of the condyle is one-half inch anterior to the external auditory meatus and just below a line drawn from the bottom of the meatus to the anterior nasal spine. In many patients the end of the condyle may be easily felt through the tissues covering it; in others by placing the index-finger just inside the external auditory meatus, the thumb on the surface of the face just anterior to the position of the condyle, then, requesting the patient to open and close the mouth, the location is determined.

Fig. 334

Patient with the external end of the head of the condyle located and marked on the skin.

The bite-plates are then returned to the mouth with the stem, which is now attached to them, projecting between the lips. The bow is put in place, with the stem entering the movable clamp which slides upon the bow, and with the two projecting end pieces of the bow accurately placed over the condyles as indicated by the pieces of court-plaster on the skin. It is necessary to see that the two project in equal amounts

from the bow before the milled clamps which fix them are tightened, because, when the casts are to be mounted on the articulator, and these end pieces are pushed completely in, they just reach the external end of the joint mechanism of the articulator, and this precaution is necessary to assure a centering of the casts. If this were not done, that is, if the two end pieces project unequal amounts when the bow is in position on the face, the casts will not be centered when they are transferred to the articulator. When this has been done, the movable clamp, which fixes the stem to the bow, is tightened, care being taken that the patient's jaws are firmly closed in the bite-plates, and that the end pieces have not moved from their positions over the condyles. (Fig. 335.)

Fig. 335

Patient with Snow face-bow in place.

The bow, stem, and bite-plates, firmly attached together, are now removed. The casts are now put in position in the bite-plates, and the projecting end pieces are pushed as far in as they can be, and the milled nuts turned to fix them. The casts are now to be tried upon the articulator with the holes in the end pieces fitting over the projections upon the outer side of the joint mechanism. After the casts shall have been mounted upon the Gritman articulator, the general plane of the alveolar ridge of the cast should be as nearly parallel with the upper bow of the articulator, as it may be set by a rotation the bow and casts attached thereto about the joints of the articulator. The object of this is that this plane may make the correct angle with the slot in the articulator, which determines the path of the portion corresponding to the condyle. The articulator is so constructed that the angle formed by this slot and the upper bow of the articulator, corresponds to the average angle formed by the path of the condyle and the plane of the upper alveolar process in a large number of cases examined by its designer. If the upper cast has been properly formed in the first place so that its base is parallel to the general alveolar plane, it is only necessary to see that its base is parallel to the upper bow, and the proper angle will be formed between its alveolar plane and the slot at the joint. The screw with a jam-nut, which regulates the distance between the bows of the articulator, should be screwed tight and the casts may be trimmed, if this is necessary, in order that they may be accommodated between the bows, or the lower bow may be separated from the upper by sliding it downward and fixing it at the proper distance by means of thumb-screws arranged for the purpose.

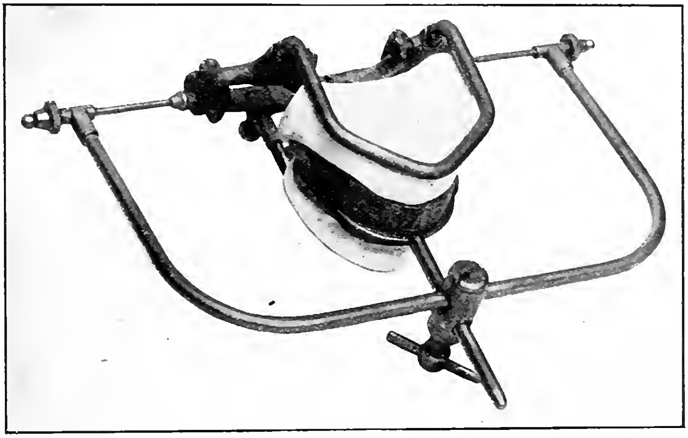
When the Snow face-bow is used in conjunction with the New Cen-

tury articulator or any other with adjustable condyle paths with which it may be employed, it is not necessary to take these precautions about having the general alveolar plane of the casts parallel with the bows of the articulator for the reasons above mentioned, because the condyle paths are subsequently adjusted to the proper angle. However, as a matter of convenient positioning of the casts this plan will, under these circumstances, be found advantageous.

When the casts have been properly adjusted (Fig. 336), they are fixed in place by additions of plaster, and the casts are ready for the subsequent setting of the teeth.

The Snow face-bow was designed for use with the Gritman articulator, but it may be used with the Walker or Christensen articulator, if these

Fig. 336



Snow face-bow.

are altered slightly by the addition of projections at their joint-mechanism to receive the projecting ends of the face-bow. Since the advent of the New Century articulator, with which it may be very conveniently employed, the results obtained in tooth articulation by the use of this combination of instruments have been most satisfying.

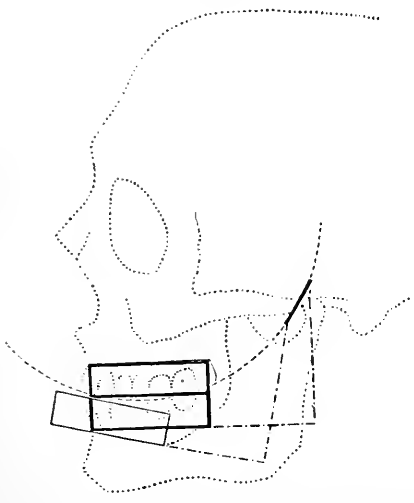
THE DETERMINATION OF THE PATHS OF THE CONDYLES

It was shown in Chapter IV. that in the typical natural dentures there is a definite relation between the paths pursued by the condyles, in their forward and lateral excursions, and the forms and arrangement of the occlusal surfaces of the teeth, and that during the sliding contact of the teeth the path pursued by the mandible is determined by the teeth on its anterior extremity and the condyles and glenoid fossæ posteriorly. In the articulation of artificial teeth, it is desirable that they should be arranged in such a way that the sliding contact may be possible during their use. In order to accomplish this, it is necessary, therefore, that they be set up to accord with the paths pursued by the condyles in the

individual case requiring them. This demands that the paths of the condyles be ascertained, if this be possible, and that an articulator capable of imitating these movements be utilized in setting the teeth, and that it be set to imitate the condylar paths in the given case. No articulator has yet been constructed which is exactly able to reproduce these movements, but of the several anatomical articulators already described, all possess sufficient accuracy to make them of some service, and while no one of them is perfect, the use of them greatly improves the results in the articulation of the artificial teeth.

Given a satisfactory articulator, it then becomes necessary to have some means of ascertaining the paths pursued by the condyles of the edentulous jaw for which the denture is to be made. These must then be recorded by some means, and the record transferred to the articulator. This is a somewhat difficult matter, as in the living subject the condyles and fossæ are beneath the skin, and this makes it impossible to directly observe the operation of the joint. Campion[1] has devised a means of accomplishing this by the use of a bow carrying two points; the bow is attached to the teeth of the lower jaw, and the points are placed over the external ends of the condyles previously located. The points carry a pen or pencil, and the position of the condyle at any position of the lower jaw is recorded by a mark upon the skin of the face and the record may then be transferred to a piece of paper. This method is chiefly for use in studying the movement of the mandible, and is not designed for use in the setting of artificial dentures. Walker has, however, designed a method for determining the condylar path on each side independently, which he applied in the construction of dentures. He used a complicated apparatus which he called a "facial clinometer," by means of which the angle between the path of the condyle and the plane of the upper alveolar process was determined, and the articulator bearing his name set according to this for the case under consideration. The apparatus is so complicated that it has never come into general use.

Fig. 337



Schematic drawing, showing relation of dentures in position of occlusion and in forward position of mandible. (Christensen.)

Christensen[2] has proposed a method for harmonizing the articulation of the teeth with the movement of the condyles. His method is based

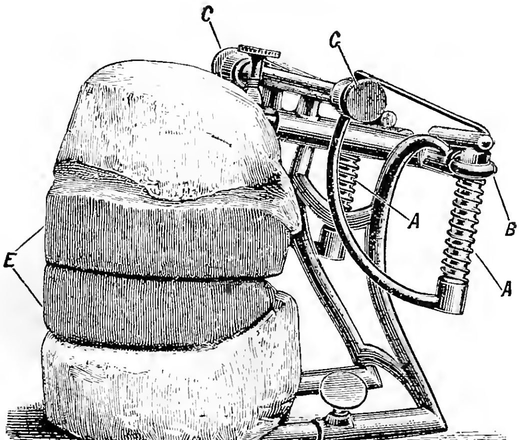
[1] Method of Recording Graphically the Movements of the Mandibular Condyles in the Living Subject: George C. Campion. The Dental Digest, 1903, p. 841.

[2] A Rational Articulator. By Carl Christensen. Quarterly Circular of C. Ash & Sons, December, 1901, p. 409.

upon the following facts, to which he calls attention. During the movement of the mandible in the individual with natural teeth, while these teeth preserving a sliding contact, the condyle can move only from its distal position downward and forward a distance of 4–5 mm., with 12 mm. as the probable maximum. It is during this sliding contact of the teeth that the movements of the condyle occur which are important from the standpoint of the function of the denture: we are only concerned with such movements of the condyle. Therefore, the path of the condyle would be a curve of large radius, or, for all practical purposes in tooth articulation, would be a straight line. If an articulator could be set so that the parts representing the paths of the condyles would be either identical or concentric with those actually pursued by the jaws, the teeth could be set up according to this and would articulate when placed in the mouth. Christensen's articulator is used upon this principle.

The bite is taken in the ordinary way and the casts are mounted upon the articulator with their median line corresponding to the centre

Fig. 338



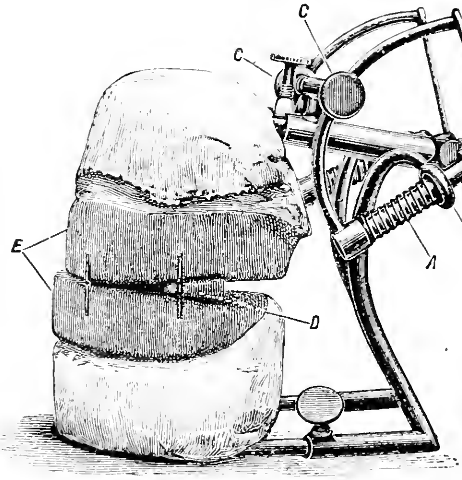
Casts mounted on Christensen articulator, in position of occlusion. (Christensen.)

of its bows, and the line between the positions of the lower central incisors, 10 cm. from each joint, representing the temporo-mandibular joint. (Fig. 338.) If the bite-plates are then returned to the mouth, with a small lump of soft wax upon the occlusal portion of the upper bite-plate, and the patient is instructed to throw the lower jaw forward and then to bring the bite-plates together, a record is made of the jaws in this position. (Fig. 337.) If the casts already mounted upon the articulator can be placed in the bite-plates, the former will then assume the position occupied by the jaws, and if they were originally placed upon the articulator in the same relation to those portions of it representing the condyles, these latter must now be in the position of the condyles in the forward position of the mandible. The path of the condyles to this

point is approximately a straight line, and as we have the distal end of this line recorded on the instrument when the bite was taken, we now have its anterior end determined, because the bow of the articulator, like the mandible, moves as a whole. If the portion of the articulator, therefore, which represents the path of the condyle (the bar with the spring and sliding ring) is set in this position by screws, C and C (Fig. 339), the casts may then only be moved in relation to each other as the sliding of the rings on the bars will permit, and they thus imitate the movements of which the jaw is capable.

It will be seen at once that this imitation of the jaw movement by the articulator cannot be mathematically precise, because of probable errors

Fig. 339



Casts arranged in forward position of mandible by means of bite-plates; articulator adjusted thereto. (Christensen.)

in the record, and because there is some play in the natural joint which no articulator can ever imitate. It is sufficiently accurate, however, to give results in tooth articulation which far excel those obtained without the use of an articulator capable of individualizing the movements of the condyles.

Since the publication by Gysi of the results of his work along the line of greater accuracy in securing these various records, and since the publication of descriptions of his instruments, prosthetists have been provided with a valuable addition to their armamentarium. Especial attention is directed in the following quotation[1] to the means of obtaining the balancing points in the lateral excursion of the jaw, the first recorded effort to adjust the articulator to a varying intercondylar distance.

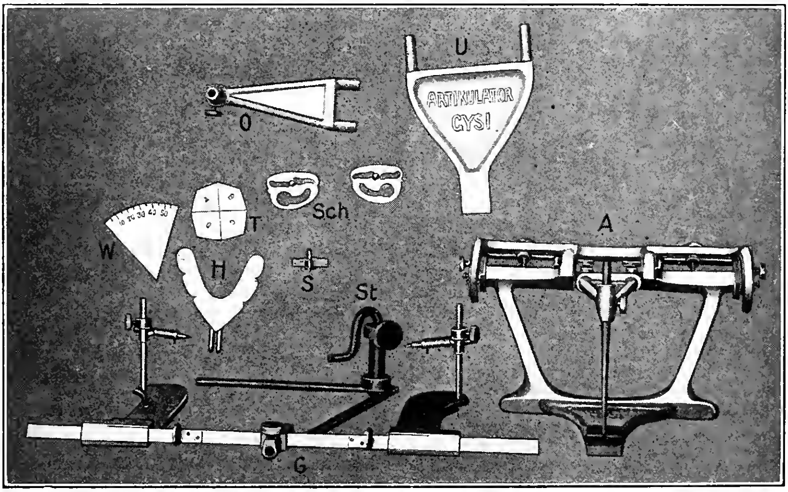
[1] The Problem of Articulation. By Alfred Gysi. The Dental Cosmos, vol. lii, p. 1. (Being a translation of Professor Gysi's book, "Beitrag zum Articulationsproblem," published by Hirschwald, Berlin, in 1908, with some practical additions written since its publication.

THE GYSI MEASURING INSTRUMENTS.

"According to Bonwill, the two condyles form an equilateral triangle with the contact point of the lower central incisors. I have, therefore, constructed two measuring instruments. With the one (Fig. 340, *G*) I determine, from the forward and opening movements and the combination of these two, the form and direction of the two condyle points of the triangle in a vertical plane; with the other instrument (Fig. 340, *S*) I determine, from the lateral movements, the path of the incisor point of the triangle in a horizontal plane.

"From the registered paths of these three points of the triangle in their separate directions, I can direct the movement of the mandible in all the combinations of the masticatory movements.

Fig. 340



A, Articulator; *O*, *U*, extra bows; *G*, condyle path register; *H*, horseshoe plate; *Sch*, extra pair of condyle path guides; *W*, angle measure for condyle path slant; *T*, type plate for molar groove; *S*, small register; *St*, holder for register *G* (to be used when plastering models to articulator).

"**The Large Registers for Determining the Slant of the Condyle Path.**— This instrument (Fig. 340, *G*) serves to measure the path taken by the condyles in the movements of the mandible. The important part of this instrument consists of two lead pencils, which in every individual case can be placed in the region of the condyles (Fig. 341).

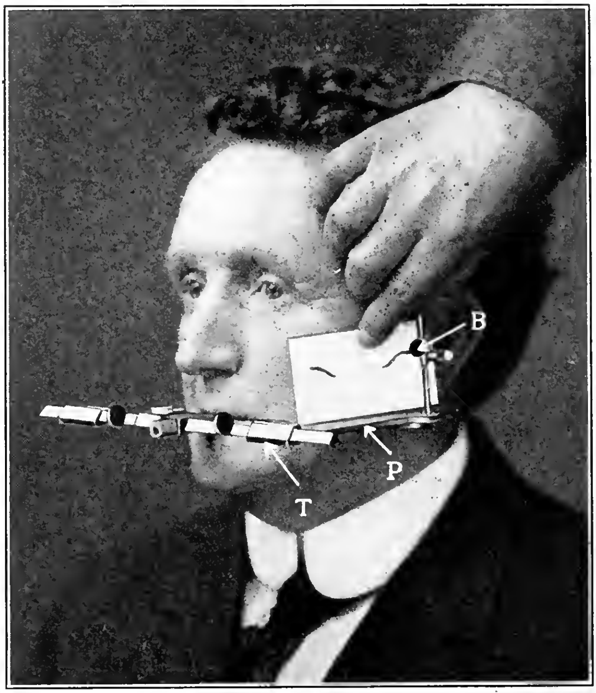
"Its attachment to the mandible is accomplished through the horseshoe plate (Fig. 340, *H*), which, with its points on the under side, is pressed into the lower wax model which has been used in taking the bite (Fig. 343). The whole is so well balanced and weighted that it will, without any further help, remain firmly in its position in the mouth.

"Parallel to the horseshoe plate (which we shall consider as being in place) on the wax model and on a line with the plane of occlusion,

parallel plates run backward on both sides (Fig. 341, P), carrying movable spring lead pencils in the region of the joint (Fig. 341, B). For extreme cases these lead pencil holders may be changed from the left to the right side, or moved up and down on their vertical bars with a screw (Fig. 340), so that the pencil points form as nearly as possible a right angle to the writing surface of the recording card (Fig. 341). The parallel plates with the lead pencils may be adjusted for individual cases by moving the plates on the cross-bar which holds them (Fig. 341, T).

"This instrument also serves as a compass, like the American Snow face-bow, which fixes the distance of the plaster models in correct relation to the axis of the joint.

Fig. 341



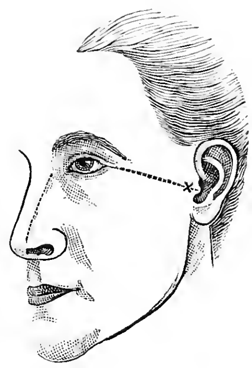
Shows the method of determining the slant and form of the condyle path. (Wilson, after Gysi.)

"In order to find out the movements of the mandible in different individuals, the wax bite-plates are prepared in the usual manner, except that the base plates must be either of modelling compound, 1.5 mm. in thickness, or of some other equal firm material reinforced in the usual way with a piece of wire. After proper attention has been paid to all the details, such as securing the proper fulness of the wax models to insure proper lip contour, the right height of the plane of occlusion, the length of the incisors, the median line of the face, etc., the patient is

directed to open and close the mouth several times, during which the positions of the condyles are ascertained by feeling in the region of the ear where they move. Then the positions of the condyles in the resting position (with the mouth closed) are found, and marked on the surface of the skin of the patient with a pencil or with chalk. Usually the condyles are found about 1 cm. in front of the tragus of the ear, in the direction of the outside corner of the eye. (Fig. 342.) The horseshoe plate is then fastened by its points to the lower wax bite-plate and both are placed in the mouth.

"If some natural teeth are left in the mandible, a horseshoe plate without points can be used. Some hot modelling compound is placed on the under side of this plate and pressed over the teeth, just as though an impression were to be taken. In most cases where there are natural teeth, it is not absolutely necessary to measure the relations of the joints.

Fig. 342



"The condyle path register is now attached to the horseshoe plate, which in its position in the mouth is fixed to the wax bite-plate. The lead pencils are put at the marked places which indicate the positions of the condyles; by adjusting them on their perpendicular bars and through the sliding arrangement on the cross-bar, they are brought close to the surface of the skin.

"The form and slant of the condyle path will then be found by inserting a piece of cardboard, as shown in Fig. 341, between the pencil points and the skin in the region of the joint, with the lower edge parallel to the parallel plates of the register. The latter plates are again moved on the cross-bar until the pencils are brought in such close contact to the writing surface of the card that the springs holding the lead pencils are under a pressure. The patient is directed to move the mandible up and down, and from side to side (chiefly the latter motion), until the condyle path is clearly drawn on the surface of the recording card. (Fig. 341.)

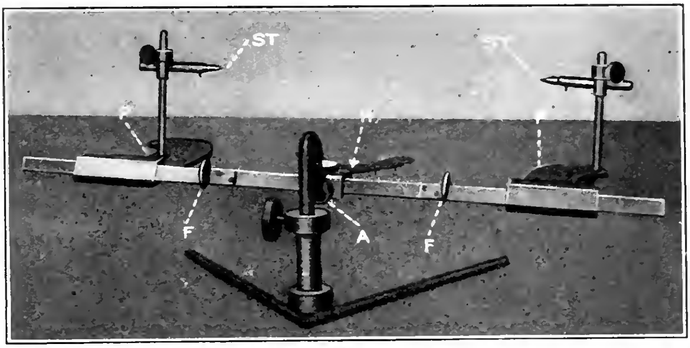
"The lateral movements of the mandible show that the curve first made by the opening and closing movements is followed in the lateral movements, and that while one condyle moves forward, the other moves more or less backward. (See explanation to Fig. 348.) The measuring of this moving path of the mandible occupies hardly three minutes' time.

"After one side of the mandible has thus been measured, the same card is held on the other side, and the same procedure is again followed. After the measuring is finished, the lead pencils are moved outward by the sliding arrangement on the cross-bar, so that the recording card and the register may be taken away, without, however, removing the horseshoe plate. The lead pencils with their holders must not be moved or turned on their vertical bars, as their position is of importance

in attaching the models to the articulator, as we shall see later. The wax models may then be taken from the mouth.

"To find the angle of the registered path in relation to the occlusal plane, a slotted plate is selected which corresponds as nearly as possible to the form of the registered path. The plate chosen is placed directly over the lead pencil drawing, so that the drawn line can be seen ap-

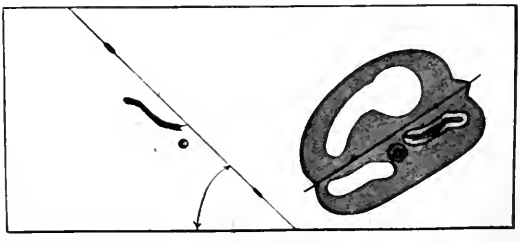
Fig. 343



Shows the condyle register with the horseshoe plate attached, to which the lower wax bite-plate is fastened: *ST*, spring lead pencils; *P*, parallel plates; *H*, horseshoe plate; *F*, finger rests; *A*, place for inserting holder.

proximately parallel to the sides of one of the slots (Fig. 344). Press the point of the axis of the slotted plate through the card, and then mark the points of the long axis of the plate with a pencil. This will show the main direction of the path. The slotted plate is taken away, and both marked points are joined by a direct line (Fig. 344), which line

Fig. 344



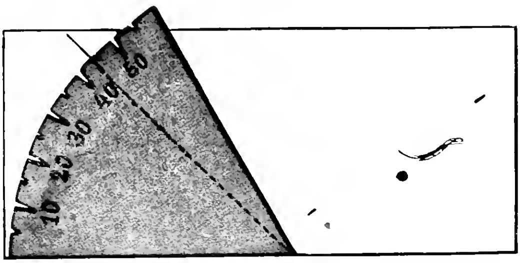
Shows how the main direction of the condyle path is found by means of the slotted plate.

is continued to the lower boarder of the card, so that with the angle measure one can determine (see Fig. 345) the acute angle which this line forms with the lower border of the card. As this lower border of the card is held (in the registering of the path of the condyles) parallel with the parallel plates, which in turn are parallel to the horseshoe plate, and this latter lies in the plane of occlusion, the angle measured

in this way must correspond exactly with the slant of the path of the condyle to the plane of occlusion.

"The slotted plate chosen is then placed in position on the articulator and the known slant fixed by means of the engraved degree scale on the joint of the instrument (see Fig. 331). Then proceed in the same manner with the registered condyle path of the other side.

Fig. 345

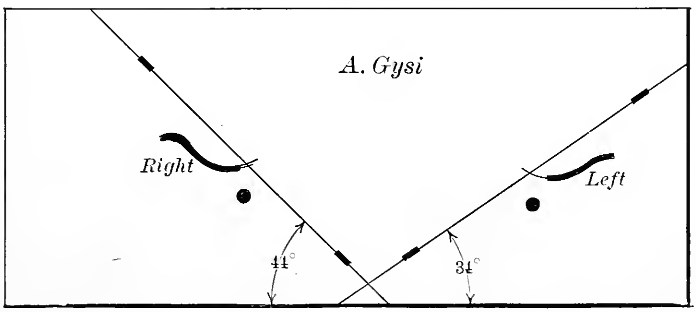


Shows the mode of measuring the angle formed by the condyle path and the lower border of the recording card.

"Fig. 346 shows a recording card with the registered condyle paths of the right and left sides, which have been measured in the manner stated. On the right side the condyle moves in a slant, the angle of which is 44° to the plane of occlusion (Fig. 341, P); on the left the measured angle registers 34°.

"In cases where the curve is more or less horizontal, and the lengthened line does not reach the lower border of the card, a line is drawn from

Fig. 346



Shows the completed measurements of the condyle path.

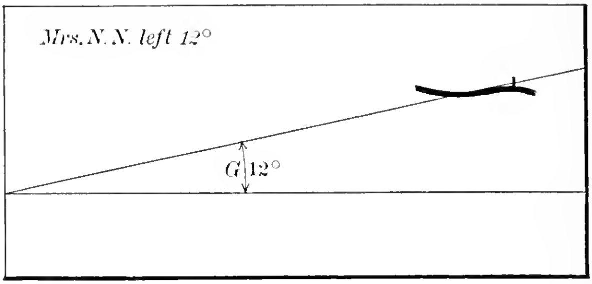
the side of the card tangent to the lengthened line and parallel to the lower border of the card (Fig. 347).

"The objection may be raised to my method of measuring that the plane of occlusion represented by the wax bite-plate is not a fixed point, because in setting up the artificial teeth one is obliged to change this temporary plane of occlusion according to circumstances.

"This objection, however, is only apparently justified, because in reality not only the angle of the condyle path to the temporary plane of occlusion is obtained, but also at the same time that to the alveolar ridge, or to the mandible itself as a whole.

"If the temporary plane of occlusion is changed, the degree of the angle of the condyle path is, of course, also changed to agree with the

Fig. 347

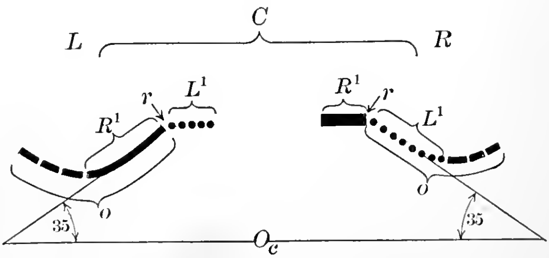


new plane of occlusion, but the relative relations of the position of the mandible itself to the condyle path remain just the same.

"I will now give an analysis in detail of the condyle path curve as illustrated in Figs. 344 and 346.

"Fig. 348 shows an enlarged diagram of a left and right condyle

Fig. 348



Analysis of a right and left condyle path as secured by method shown in Fig. 341: *C*, condyle path; *L*, left; *R*, right; *Oc*, plane of occlusion; 35-degree angle of middle part of path to plane of occlusion; *r*, resting position of condyle; R^1, path of condyle in a right lateral movement; L^1, the same in a left lateral movement; *o*, forward bite or wide opening and closing movement.

path curve, each of which is divided into its chief parts, as indicated by the different lines.

"From the description of this diagram it can be seen that during the forward and downward movements of the one condyle, the other runs more or less backward horizontally.

"The extreme forward movement and the opening and closing movements may be divided into two parts: First, the path which the con-

dyle takes in a slight lateral movement, and second, the path which the condyle takes in its movements on the eminentia articularis, which is more or less horizontal, and, finally, may even lead upward.

"As the last part of the path as represented by dashes in Fig. 348 can only occur in extreme lateral or wide opening movements, and is of no importance in mastication, I determine only the degree of the angle of the more important middle part of the curve to the plane of occlusion. (In the case represented in Fig. 348 the angle registers 35 degrees.)

"It does not often happen that both condyle path curves have the same form and slant. Some examples of the differences in form and slant between left and right condyle path curves in the same individual may be seen in Fig. 351, *a* to *i*. The specimens in the same figure from *m* to *q* show that other differences may occur, either in only one or in both joints at the same time, between the path of the opening movement and the path of the lateral movement (*n* to *q*). For prac-

Fig. 349

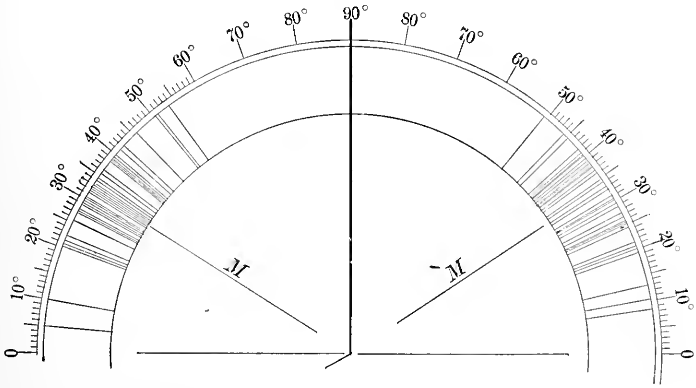


Diagram of a number of condyle path angles. (See table.)

tical purposes only the path taken in the lateral movement possesses any value in the setting up of the artificial teeth for effective mastication, and, therefore, only this angle is measured.

"In Fig. 349 I have compiled a number of condyle path angles, and from these statistics it can be seen that the average angle is about 33 degrees.

"The accompanying table shows the same cases individually arranged, and it may be seen from it that in about half the cases there is a difference of only about 4 degrees between the right and left side. As this slight difference might be attributed to a possible mistake in measuring, it can be truly said that half the cases which I have measured had the same condyle path angle on both sides, and the other half showed a difference of between 5 and 22 degrees, averaging about 10 degrees. One astonishing case of exception showed 51 degrees on the right side and 10 degrees on the left side, a difference of 41 degrees.

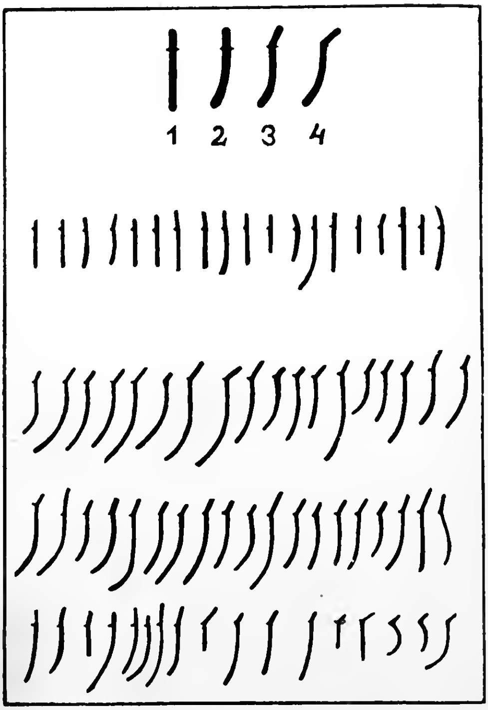
EXAMPLES OF ANGLES OF THE CONDYLE PATH.

(Same cases individually arranged.)

Right.	Left.	Difference	Right.	Left.	Difference.
54°	54°	0°	33°	38°	5°
40°	40°	0°	43°	38°	5°
33°	33°	0°	35°	30°	5°
51°	50°	1°	30°	25°	5°
26°	27°	1°	26°	20°	6°
39°	37°	2°	28°	20°	8°
28°	30°	2°	21°	13°	8°
23°	21°	2°	40°	32°	8°
35°	37°	2°	10°	19°	9°
40°	42°	2°	34°	25°	9°
32°	35°	3°	22°	31°	9°
31°	34°	3°	30°	40°	10°
33°	36°	3°	28°	39°	11°
37°	40°	3°	40°	25°	15°
5°	9°	4°	29°	45°	16°
36°	40°	4°	46°	29°	17°
10°	14°	4°	23°	45°	22°

"Fig. 350 shows a collection of condyle path forms, from which I have chosen the four average types that are used in my articulator in the

FIG. 350

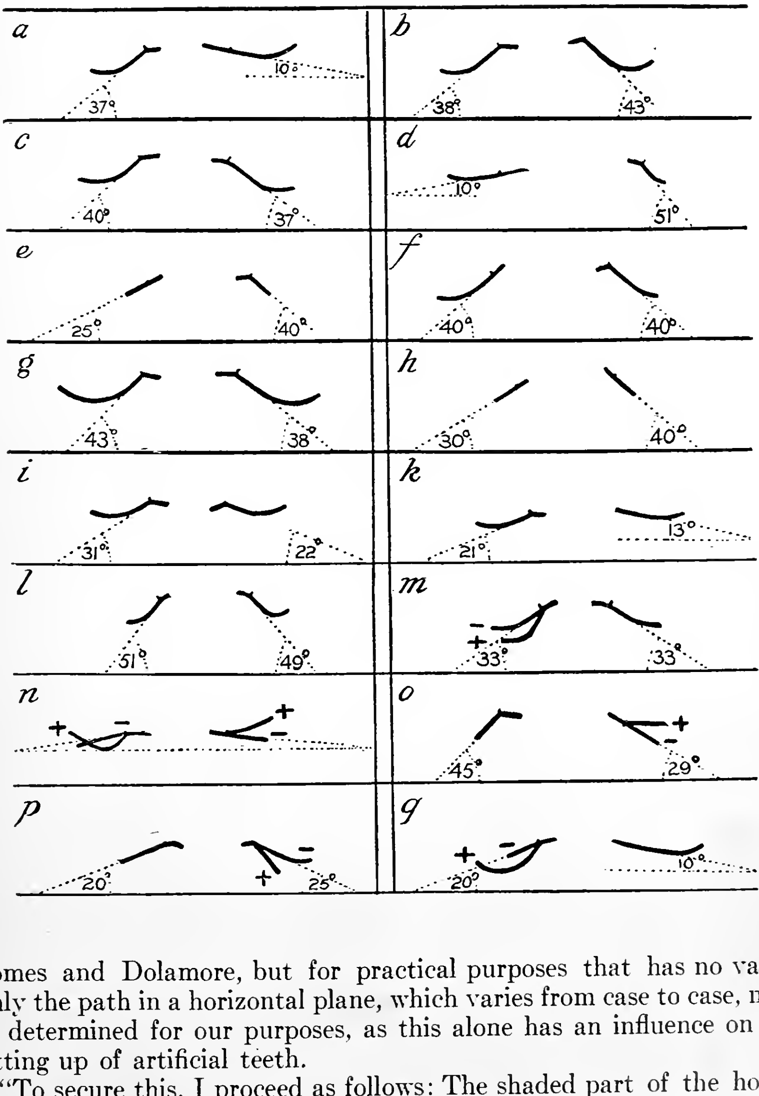


The four average forms of condyle paths. Examples of condyle path forms as registered in edentulous patients.

form of the slotted plates represented in Fig. 344. If necessary, other forms may be made from thin brass plate. These slotted plates are the condyle path guides of the articulator.

"**The Small Register. Instrument for Determining the Path of Motion of the Anterior Triangle Point in a Horizontal Plane.**—The movement of this point in a vertical plane in the opening and closing movement has, as has already been stated in the opening chapter, been measured by

Fig. 351



Tomes and Dolamore, but for practical purposes that has no value. Only the path in a horizontal plane, which varies from case to case, need be determined for our purposes, as this alone has an influence on the setting up of artificial teeth.

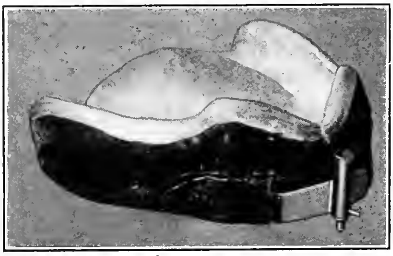
"To secure this, I proceed as follows: The shaded part of the horseshoe plate, as shown in Fig. 353, is covered with a thin film of dark-

colored wax, which with a hot instrument is spread to the thinness of paper.

"A pointed marker (the small register) mounted on a spring is now pressed directly over the median line of the upper wax model after having been warmed slightly, and with a hot instrument is firmly attached at the edges. The point must stand out about 1 mm. over the occluding surface of the wax model (Fig. 352).

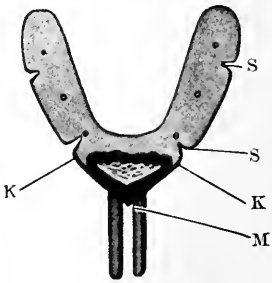
"The upper and lower wax models are again placed in the mouth and held in position by a little tragacanth powder, and the patient is requested to move the mandible from side to side. The point of the marker registers these movements on the coating of wax on the horseshoe plate. At first these recorded movements are somewhat irregular and intertwine at the posterior portion of the wax-covered part of the plate (Fig. 353), because in the beginning the patient pushes the mandible too far forward. Without an effort to correct this improper position of the mandible, this movement is allowed to continue, and it will be seen that the mandible, owing to fatigue, will gradually go back to its normal

Fig. 352



The small register fastened to the upper wax model.

Fig. 353



Horseshoe plate with registered incisor path.

distal position, and its path will be recorded by a correct regular curve (K M K).

"The outer line of these tangled markings is the normal path, the middle is the true median line, and also the normal closing point in the resting (occlusal) position of the mandible.

"When the point of the marker is at M (Fig. 353) or in resting position (Fig. 354), the usual marks are made on both wax models at the notches prepared in the horseshoe plate (Fig. 353, S S) to show the proper positions of the models when being fastened with plaster to the articulator.

"This instrument is of great service in the use of any articulator, because, leaving aside its special purpose, which will be explained later, it is an excellent help in securing the normal resting position of the mandible.

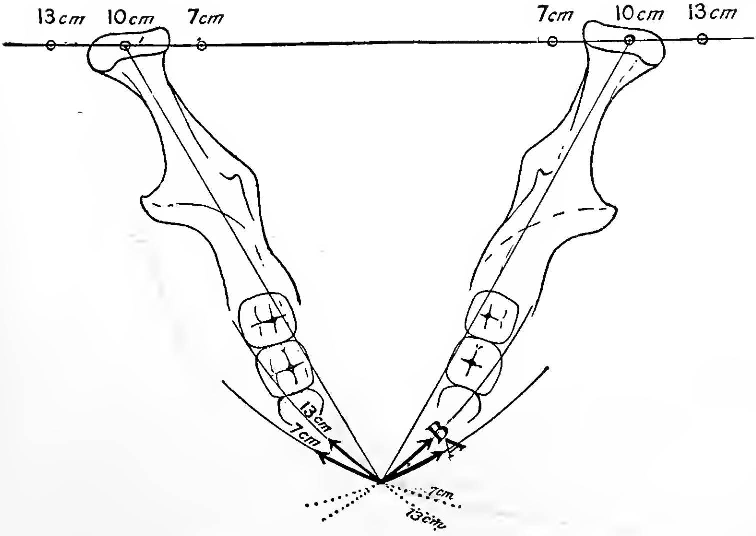
"From the angle K M K the relative position of the balancing or rotation points of the mandible can be determined (Fig. 355).

"If both sides of this angle are extended beyond the intersecting

Fig. 354

Registering the incisor path. (Wilson, after Gysi.)

Fig. 355



point (see dotted lines in Fig. 352), the direction of the path of the lower incisors and canines during mastication is shown.

"This angle of the incisor path varies in different individuals, and therefore the center of rotation varies correspondingly. In my investigations I have found that the relative distances between these rotation points may vary from 7 to 13 cm. measured by a line drawn through the centre of the condyles.

"In some cases these rotation points may lie still farther away from the condyles. As the average distance (according to Bonwill) between the condyle centres is 10 cm., the rotation point may lie sometimes inside and sometimes outside of the condyles. Very often the rotation point in the same individual may be differently situated on each side, *e. g.*, the one may lie inside, and the other outside the condyle.

"The importance of determining the exact position of these rotation points can be best understood by making a drawing like that in Fig. 355 on a triangular piece of cardboard, and recording the movements of the incisor point of the triangle by sticking a pin successively through the balancing points of 7, 10, and 13 cm., and with a sharp lead pencil point inserted through the incisor point recording the lateral movements. The result will show three different paths.

"Figure 356 shows how both condyles carry out the same movement (in lateral movements) when the rotation points lie outside of the condyles 12 cm. apart, while the lead pencil points attached to the large register will mark paths in the opposite direction.

"Figure 357 shows how both the condyles and the lead pencil points of the large register will record opposite paths in the lateral movements when the rotation points lie inside the condyles.

"It is clear from these two illustrations that it is possible to determine the position of the rotation points from the relations of the paths (of the forward movements on the right sides and the backward movements on the left sides of Figs. 356 and 357) recorded by the registering instrument; but this method would not be accurate enough, owing to the short length of the paths, and, therefore, from even small mistakes in measuring great differences would arise.

"From the position of these rotation points it is plain that they could not be considered as anatomically fixed points, but rather as ideal balancing points, and for that reason their existence has remained unrecognized so long. Walker recognized their existence in 1896.[1]

"A balancing point is, therefore, the axis of rotation resulting from the diverse contractions of the masticatory muscles, and happens to coincide only now and then with the condyles. As it is impossible to imitate the muscles of mastication on an articulator, these balancing points must be substituted by mechanical centres of rotation, the positions of which can be changed from case to case.

"The natural condyles cannot be considered as true rotation points or axes around which the various movements of the mandible occur, but

[1] See Dental Cosmos, January, 1896, p. 34, and July, 1896, p. 573.

should only be regarded as fixed guides of the mandible in its movements.

FIG. 356

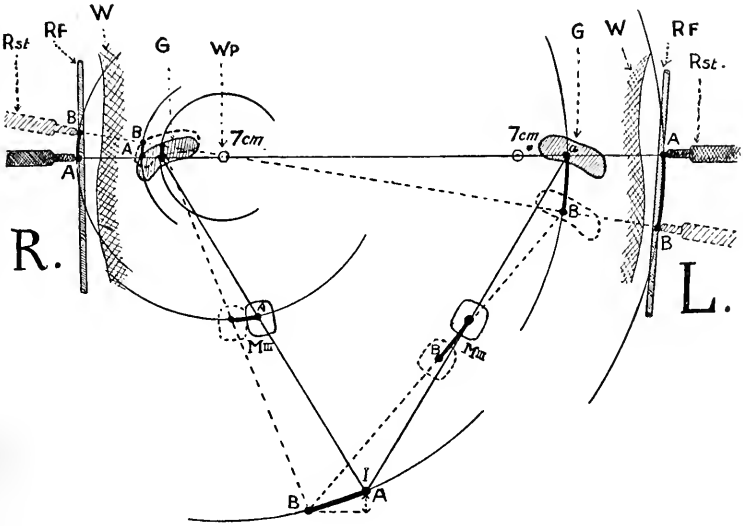
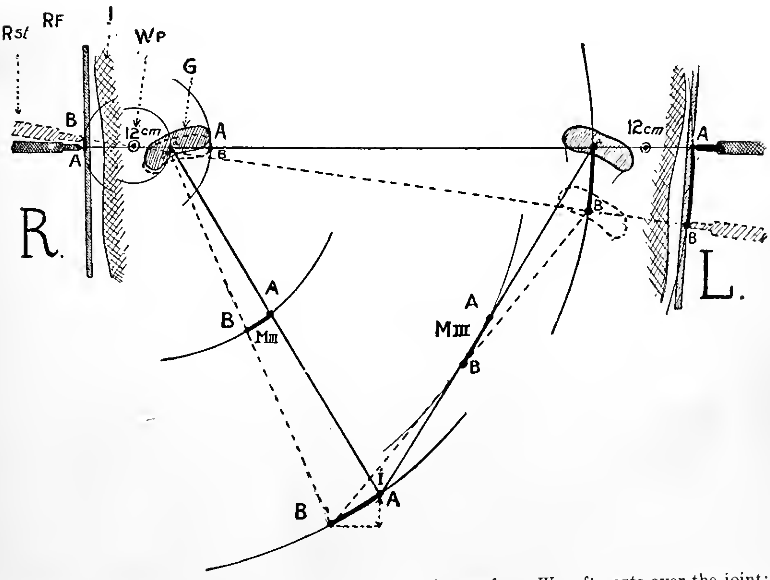


FIG. 357



FIGS. 356, 357.—*Rst*, Registering point; *RF*, registering surface; *W*, soft parts over the joint; *Wp*, balancing point; *G*, condyle; *A*, *B*, moving path of the chief points of the mandible and of the registering points in lateral movements.

"It is, therefore, not necessary to try to imitate the natural condyles nor the glenoid fossa on an articulator, but it is necessary to imitate the

muscle movements by constricting mechanical centres of rotation (as already stated) and mechanical condyle path guides, as represented in my articulator by slotted plates.

Fig. 358

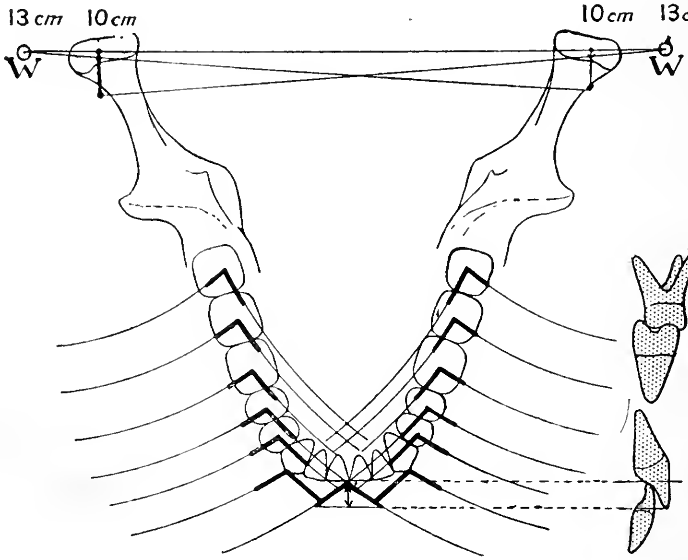
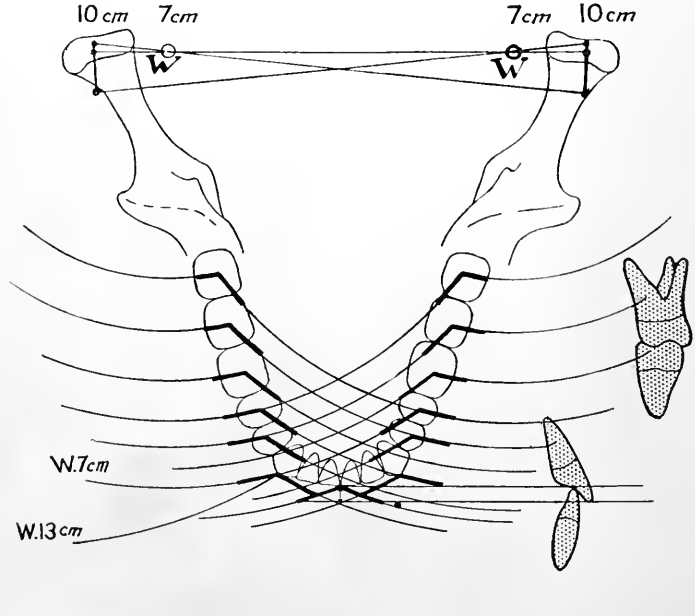


Fig. 359



"The importance of knowing the relative position of the balancing points is made clear in Figs. 358 and 359.

"These balancing points can be constructed either geometrically with compass and rule, or simply by drawing on a piece of cardboard an equilateral triangle with sides of about 13 cm. in length, on which the outline of the mandible is drawn, with the teeth as in Figs. 358 and 359. Attach with wax small graphite points between the central incisors, also over the canines, and over the middle of each molar. Grind these points to an equal height with a piece of sand-paper. Set the cardboard with the points downward on a piece of writing paper, insert a pin through the middle of each condyle, and make lateral masticating motions with the cardboard, when the graphite points will record their individual movements. If the same experiment is made with the pin inserted through the extreme balancing points of 7 and 13 cm. distance, quite different results will be obtained. These two-dimensional tracings as shown in Figs. 358 and 359 are not quite accurate; the angles would be slightly different in a normal natural case, where there is an overbite of incisors, and, therefore, a three-dimensional movement.

"In cases where the balancing points lie outside of the condyles, the mandible in lateral movements moves at the same time strongly forward. As the lower incisors are, however, somewhat hindered by the overbite of the upper incisors, the mandible glides downward and outward on the lingual surfaces of the upper incisors; consequently a longer overbite of the canines and higher cusps of the molars are necessary in order that the teeth may not move too quickly away from each other.

"When, however, the positions of the balancing points lie inside of the condyles, the lower incisors move forward less obliquely and almost directly sideward, thereby for some distance the contact with the upper incisors is secured; consequently the overbite may be less and the cusps of the molars may be lower.

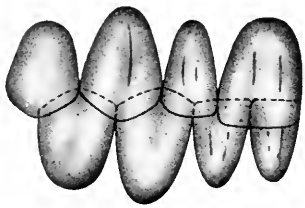
"The positions of the balancing points are still more important in regard to the relative positions of the upper and lower canines. To present this fact more clearly, the path of the canine in Fig. 358 is presented on the left side of Fig. 359, showing the difference in the paths of the lower canines according to whether the balancing point of 7 cm. or of 13 cm. asserts itself.

"Fig. 360, for example, shows a side view of the canines in the normal occlusion as they are usually set up in an articulator for a practical case. Fig. 361 shows the same in a lateral movement. If, however, the patient has a difference balancing point, the canines will describe another path, and the upper canine will not pass properly through the space between the lower bicuspid and canine, but will rather strike against the cusp of the latter, thus forming the only contact point of the tooth rows, and thereby tilting and loosening the upper plate (Fig. 362). With such an artificial denture lateral movements are absolutely impossible, and the patient in eating is compelled to carry on only up and down movements, or else ultimately the cusps of the canines as well as those

of the bicuspids must be ground off, whereby the natural appearance and usefulness of the denture is destroyed.

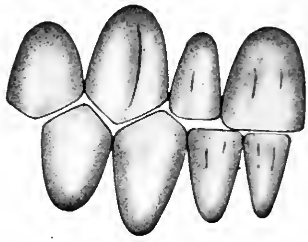
"As I have already stated, the mandible cannot make a free lateral movement, being partly prevented by the overbite of the upper incisors. Therefore the lateral movements are combined with the opening and closing movements. If no overbite were present, the front teeth in the

Fig. 360



Normal occlusion of artificial teeth.

Fig. 361

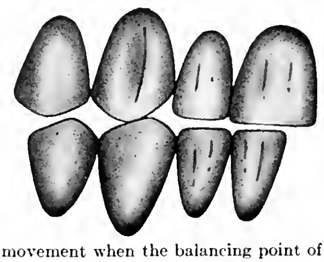


Normal position in a lateral movement when the correct balancing point has been secured.

lateral bite would, after a short grinding movement, glide away from each other, and the whole force of the masticatory muscles would rest on the molars exclusively, so that the latter would be worn away altogether too quickly. These conditions may be noted in the ruminants (horses, cows, etc.); the increased wearing away of the molars is, however, compensated by their numerous and deep enamel folds.

"The upper incisors, because of their slanting surfaces on the lingual side, have the important function of acting as the anterior guiding and

Fig. 362



Incorrect position in a lateral movement when the balancing point of the articulator differs from the natural one.

gliding plane of the mandible, while the condyles and the eminentia articularis act as guides of the posterior movements of the mandible. These latter guiding planes of the two posterior points of the triangle have a slant of from 5 to 50 degrees, while the anterior point of the triangle or incisor guide exhibits a slant of from 50 to 70 degrees to the occlusal plane.

"In edentulous patients it has been impossible so far to determine the previous guide angle of the incisor. I believe, however, that this rep-

resents a racial phenomenon, directly dependent upon the facial angle. From a small number of measurements I have found that the angle of the slant of the lingual surfaces of the incisors, which form the incisor guide, amounts to 15 degrees less than the facial angle formed by a line connecting the outer ear with the base of the nose, and a line connecting the most prominent part of the forehead with the base of the nose. These measurements are, however, too small in number and too superficial to serve as full proofs.

"If the angle of the guiding surfaces of the incisors is determined in such an arbitrary way, it is of no practical value in an artificial denture. For practical reasons, which will be discussed in a subsequent chapter, I nearly always choose the lowest angle, of about 45 degrees or less, for this gliding angle of the incisors.

"From all these considerations it follows unquestionably that in lateral movements the centres of rotation or balancing points lie approximately on a line passing through the centre of the condyle region, and that these balancing points in different individuals may lie either on the inside or the outside of the condyles.

"As I shall show later, the mandible in opening and closing rotates around another centre, which, however, has no influence in the setting up of the teeth for articulation, and, therefore, need not be considered in the construction of an articulator. In the Walker articulator this opening axis can be attached, and is used when the plane of articulation is to be lowered or raised. In the Kerr articulator the true axis of rotation on opening is permanently fixed on the articulator. In my articulator the ordinary axis for opening and closing movements is used—as it has no influence on the slant of the condyle path—in the same way as in Walker's and Christensen's articulator.

"From these observations it follows that in the construction of an articulator the following points should be considered:

"1. An individually changeable slant of the condyle path.

"2. An individually changeable form of the condyle path.

"3. A changeable incisor guide.

"4. Two individually changeable balancing of rotation points.

"5. The incisor guide must not change the slant of the condyle path; the slant of the condyle path must, therefore, be independent of the opening movement."

CHAPTER XI.

THE PRINCIPLES UNDERLYING THE RETENTION OF PLATE DENTURES.

By Charles R. Turner, D.D.S., M.D.

After all the necessary data have been obtained from the patient, we are ready to proceed to the design and construction of the artificial denture. Before undertaking the design of a denture which shall fulfil the æsthetic requirement in the restoration of the facial appearance and the functional requirements of mastication, speech, etc., it will be necessary to see that a fundamental and important mechanical demand upon it is satisfied. It is essential, first, that the denture shall be adequately supported upon a base to resist the force exerted upon it in use, and second, that it shall be firmly and stably maintained upon this base during its use.

Artificial dentures receive their support from two sources—the natural teeth or roots, and the mucous membrane covering the maxilla and mandible. According as this support is derived, we have dentures divided into the following classes:

1. Crowns supported upon natural roots.
2. Bridge dentures
   - A. Fixed—supported upon natural roots.
   - B. Removable—
     - a. Supported upon natural roots.
     - b. Supported both by natural roots and mucous membrane. (Saddle bridges.)
3. Plate dentures
   - A. Maintained and supported by roots and mucous membrane.
   - B. Maintained by teeth—Supported by membrane. (Clasp dentures.)
4. Plate dentures receiving their support solely through mucous membrane, and maintained independent of natural teeth.

The first two of these classes are so important that they will be considered separately in succeeding chapters (XVI. and XVII.), and this chapter will treat only of the last two, or plate dentures.

The mucous membrane covering the maxilla and mandible is normally firm, resistant, and comparatively insensitive. It affords to a carefully adapted base-plate upon which are mounted artificial teeth, sufficient support to withstand the force exerted in mastication, provided the base-plate area is adequately proportioned to the number of teeth it carries, and hence to the stress which devolves upon it in use. Under these conditions the support is afforded by the membrane without protest, the bony substructure being of sufficient strength to bear the stress transmitted to it. Plate dentures depend wholly upon the mucous membrane for their support, with the exception, however, of the small number of plates which receive additional sup-

port from teeth or roots whose chief function is the maintenance of the appliance. These exceptions are so-called removable saddle bridges, dentures combining the principles of plate and bridge-work, and some partial plate dentures.

RATIONALE OF THE METHOD OF USE OF PLATE DENTURES

The satisfactory utilization of a plate denture for purposes of mastication depends also upon its firm maintenance in position upon its supporting base. This usually involves one or both of two things. The first is a purely mechanical consideration—the maintenance of the plate *in situ* by some physical means. The second is dependent upon the cultivation of such co-ordinations of the muscular structures of the mouth as will assist in maintaining the plate in place. It will be seen later that cases differ vastly in the physical possibilities which they offer for the stable retention of the plate, as do patients in their ability to cultivate the fine co-ordinations necessary for the successful use of the denture. Just as the former are less in amount in a given case, is there greater demand upon the wearer of the denture in the latter way. Even under the physical conditions most favorable for retention, some assistance from the muscular structures will always be required of the patient. It is almost never the case that a plate is inserted and the patient can at once proceed to eat with facility. The movements which resulted in mastication with the natural denture do not succeed at first with the artificial. At best the appliance is but a substitute, and it devolves upon the patient to learn to use it. The probable success in the use of the denture may be judged in some measure by the accomplishments of the patient in other fine co-ordinations, such as sewing, or other delicate manipulations. It is unfortunate that at the period of life at which artificial dentures are usually required, the ability to acquire new co-ordinations is greatly reduced.

Frequently special effort is made to take advantage of this power of the muscular structures of the lips, cheeks, and tongue to grasp the dentures and hold them in place. It has been stated that these structures in the mouths of some patients are susceptible of great education. To utilize this power to the utmost it is advisable to form upon the buccal and labial margins of all upper dentures a projecting rim which can be grasped by the lip and cheek muscles. This becomes embedded in the tissues and affords to them a better means of grasping the sides of the plate. In some cases in which the natural conditions of the upper jaw are unfavorable to firm plate retention, it is possible to extend this principle to the point of making decided projections on the buccal surface of the plate. The author has obtained a very satisfactory result from the use of this measure in a case of syphilitic necrosis, in which one of the antra was perforated, the entire alveolar process having been lost and the roof of the mouth being almost a plane surface. The use of springs in this case seemed inadvisable because all of the lower teeth remained intact. A vulcanite plate was made with a pro-

jection in the buccal region which avoided the anterior margin of the masseter muscle and which fitted into a depression in the cheek located above the position of the risorius muscle. The patient's cheek was somewhat distended by the appliance, but in the course of time a marked depression was made in the muscular structures of the cheek, and the patient learned to maintain the denture satisfactorily in place.

Patients must learn to manipulate the food between the teeth, and to apply the force used in crushing it by such movements of the mandible as will tend to keep the dentures in place. This is often done by chewing on both sides simultaneously, and by using only the up and down motions of the mandible. A large number of full upper and lower dentures now in service admit of no other method of use, because of the form and positions of the teeth. It will be seen in the succeeding chapter that the teeth should be shaped and placed with a view of making possible the lateral movements of the mandible, which give more effective masticative results, and patients may thus acquire masticatory habits of greater utility.

Patients acquire the ability to maintain an upper plate in place by grasping it with their cheek muscles and by manipulating the tongue to support it.

In lower cases where retention of the plate promises to be difficult, and particularly where no form of partial denture has previously been worn, it is sometimes advisable to permit a tooth or teeth to remain, even when it is evident they will last but a short time. These are of great service in staying the plate and in keeping it in place upon the alveolar ridge, and serve to tide patients over that first period during which they are getting accustomed to the use of the appliance. Such teeth, of course, should be carefully preserved when they may be clasped and made of more permanent service, but reference here is made to those teeth only whose retention can be expected for a short time at best. It is impossible to estimate the value of this procedure to some patients, who, after having become accustomed to the use of the plate with the assistance of the natural teeth to maintain it, readily acquire the use of a full plate when the natural teeth are lost.

In the case of lower dentures it is always advisable to so form them that they do not encroach upon the space ordinarily occupied by the tongue. In a case in which, by reason of resorption of the upper alveolar process it is necessary to have a lower plate narrow from side to side in order that the teeth may articulate, it is advisable to make its lingual surface slightly concave: the tongue will not only fit into this space, but may, in a measure, assist in maintaining the plate in place by grasping the lower edge of the lingual surface. The extension of the distal portion of a lower plate lingually to produce a projection which may be grasped by the tongue has been recommended.[1] Where this extension would not seriously interfere with the movement of the tongue, and where in addition the tongue could obviously take advantage of the extension for the purpose indicated, it may be an advisable procedure.

[1] The Dental Cosmos, vol. xxxviii, p. 41.

MECHANICAL AIDS TO PLATE RETENTION

The purely mechanical factors which contribute to the retention of a plate are as follows:

1. Correct plate outline.
2. Correctly articulating teeth.
3. Physical means of retention.

The first two are largely negative in character in that a violation of the principles of their correct determination may become a factor to depose the denture. Pains must be taken that they do not serve to displace the plate, but are so disposed as to most favor its stable retention. The plate outline will be discussed under a subsequent heading.

In the chapter on articulation of the teeth (Chapter XII.) will be found a description of the best manner of setting the teeth to prevent a displacement of the plate. Suffice it here to say that, as far as possible, they should be arranged to receive the force of mastication in such direction as will not displace the plate through leverage, but, on the contrary, will maintain it *in situ*. This object is in part accomplished by having the distal teeth on opposite sides of the plate strike at the same time, in order to balance their separate tendencies to displace it through leverage. The physical forces of adhesion and atmospheric pressure are utilized to maintain upper plate dentures in place.

Lower dentures are held in place by gravity and to some extent by adhesion to the mucous membrane upon which they rest. Springs extending from an upper to a lower denture have been used to maintain the plates *in situ*, and partial dentures often utilize the remaining natural teeth to sustain them, attachment to them usually being by means of clasps. These several factors in plate retention will be discussed in detail.

PHYSICAL AIDS TO THE RETENTION OF UPPER PLATE DENTURES

Adhesion.—This may be defined as the molecular attraction existing between the particles of two bodies whose surfaces are in contact. It acts between two solids whose surfaces accurately fit together, or between a solid and a liquid, or a solid and a gas. The force of adhesion is directly proportional to the area of the surfaces in contact, and it offers the greatest resistance to a force tending to separate these surfaces by acting at right angles to them. Contact of the surfaces is essential to the maintenance of the adhesion, since the moment they are separated, the adhesion is broken up. Adhesion is of value more or less in the retention of all plate dentures, full or partial, upper or lower. It is of particular service in the part which it plays in the retention of upper dentures.

The retention of upper plates by this means presents a number of interesting points for consideration. The problem is to make a plate, covering the area contained within the plate outlines, which shall have

the greatest adhesion, and hence offer the greatest resistance to a displacing force. Other things being equal, the plate area should be as large as possible, since the adhesion is proportional to this area. The area is limited solely by the necessity for not encroaching upon tissues whose movements would result in the displacement of the denture. The outlines and contours of a plate should not be carried to regions where they are impinged upon by tissues moved in mastication, laughter, or speech, since the plate must not be unseated by these movements. While it cannot always be entirely free from the deposing influence of moving tissue, as in cases where it carries large contours, yet the effort should be made to reduce to the minimum all these displacing influences, and, in every case, the active forces of retention must overbalance and counteract them.

For a full upper denture the boundaries of the plates should be as follows: (Fig. 363.) Beginning at the median line of the mouth, the

Fig. 363

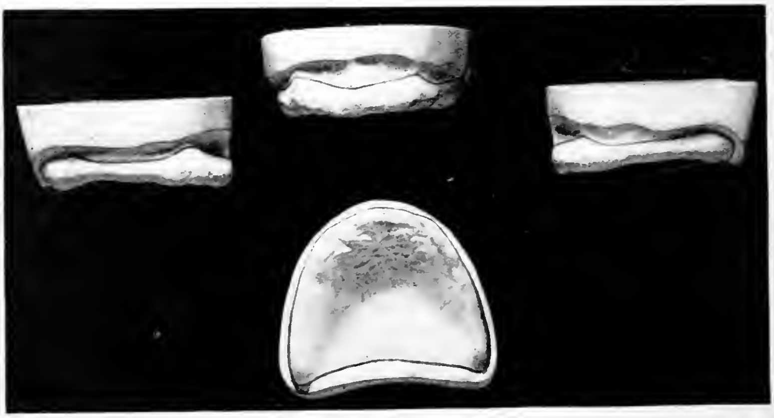


Plate outline for full upper denture.

plate outline should be placed low enough to avoid the frænum of the upper lip. It should then ascend into the incisive fossa below the line of reflection of the mucous membrane from the alveolar process to the lip, and over the canine eminence at a somewhat higher level, until it reaches the interspace anterior to the first bicuspid, when it descends to avoid the anterior margin of the buccinator muscle. It will be remembered that there are no muscular attachments to the maxilla in the incisive fossa and over the canine eminence, and, as this underlies a portion of the face which will require considerable support from the denture, the plate outline may be carried proportionately higher here than elsewhere. From the anterior border of the buccinator the boundary must be low enough to give full play to this muscle, and the several plicæ or folds of the mucous membrane extending between the process and cheek, commonly observed in this region, must be avoided. When the tuberosity is reached, the plate outline may again ascend to

a higher level, rounding it to reach the palatal vault. It must be remembered that the anterior margin of the masseter muscle is about opposite the second molar tooth, so the plate contours in this region must avoid it.

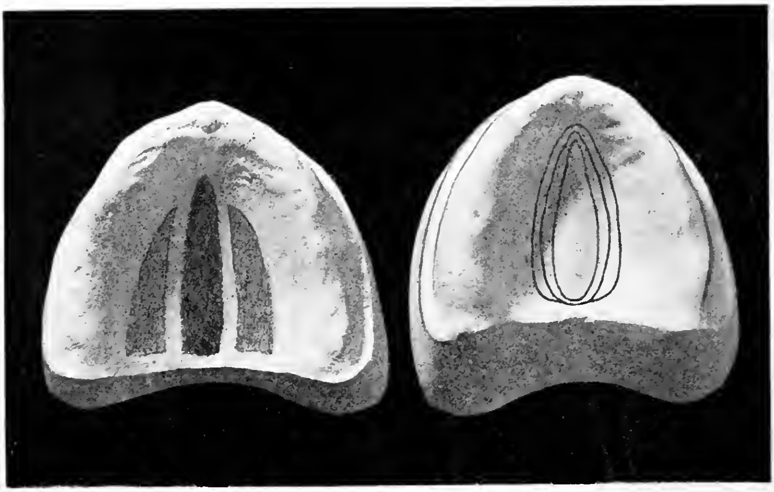
Beside giving a plate of the greatest possible area, another thing is accomplished by having the plate outline follow this course along the labial and buccal surfaces of the alveolar ridge. This provides for the exclusion of air around this part of the periphery of the plate, a condition which we have seen is necessary for adhesion. The lips and cheeks thus form curtains to cover the edge of the plate, and they constantly act as barriers to the ingress of air. So long as the lips and cheeks are closely applied to these portions of a denture, the plate may be pulled upon in front with considerable force without the admission of air at the margins and the consequent breaking up of its adhesion. This is especially true if the alveolar ridge is pronounced and has not been absorbed, and the soft tissues are attached to it externally at a high level. It is generally known that the maxilla most favorable to the stable retention of a plate denture, other things being equal, is one in which the alveolar process is well defined and which has a broad high vault. A high pointed vault affords conditions less favorable for the secure attachment of a denture, because the plate more readily slides upon the slanting sides of the vault, the ordinary displacing tendency not acting at a right angle to such surfaces; while a flat mouth, in which the ridge has almost entirely disappeared, is, of course, worst of all, because of the easy access of air to the plate edges. In proportion, however, as the tissues are attached at a high level on the buccal and labial surfaces and there has been small absorption of the ridge, is it possible to make retention secure. Closeness of the contact of these plate margins to the alveolar ridge may be accentuated by measures to be discussed later.

The posterior margin of the plate should be far enough forward to avoid any possible displacement caused by the movements of the soft palate. This line corresponds in some mouths with the end of the hard palate, while in others it is considerably anterior to this. The line of movement may be observed by having the patient open the mouth and pronounce the syllable "ah". As this is the part of the periphery of the plate where it is most difficult to exclude the air, it is desirable to have the plate extend back until its margin is laid down on soft tissue and its contact therewith accentuated. It is also desirable to avoid contact of the plate margin with the distal end of the hard median ridge, although this is not always possible. In cases of extreme difficulty it is, therefore, permissible to have the plate outline slightly encroach upon the movable area, so slightly, however, that the advantage obtained in the matter of the exclusion of air is not outweighed by the displacing influence of the palatal muscles. This advantage should be gained always where the softness of the alveolar process anteriorly permits a rocking of the plate and hence a displacement under stress in the rear. It must be borne in mind,

however, that this encroaches upon an irritable area in many throats and if the plate extends back too far, some patients may complain of nausea from this cause. In such cases a little patience and perseverance on their part will accustom them to the presence of the plate, if it be vital for retention, and, if it is not, the plate may be trimmed.

The adhesion of all full upper plates may be increased by accentuating the contact of their periphery with the mucous membrane. A judicious alteration of the face of the cast to effect this purpose is not only permissible, but is indicated in many cases. It should be done as follows: the cast should be compared with the mouth and the plate outline drawn upon it as described above. Then the tissue underlying the periphery of the proposed plate should be carefully examined

A Fig. 364 B



A. Full upper cast showing hard areas heavily shaded and soft areas lightly shaded. B. Full upper cast showing hard median ridge, with lines drawn to show size of three layers of tin foil to be added for purposes of retention.

digitally to estimate its compressibility. This is to determine how much it may be safely compressed by the margin of the plate. In some mouths the mucous membrane around the buccal and labial alveolar walls is so dense, or thin, or closely adherent to the underlying bone, that it will bear only slight compression, while in others it is soft and may be compressed perceptibly without protest. The cast (Fig. 364), should be slightly scraped along these corresponding areas, so that when the plate has been formed upon it, or upon a die made from it, the contact of the plate margins will be accentuated. The amount to be removed from the cast is slight even in cases requiring the greatest alteration, and around the buccal and labial walls never exceeds $\frac{1}{100}$ to $\frac{1}{50}$ of an inch in thickness. Across the palatal vault at the posterior margin a greater amount may be removed; proportionately, twice as great as that taken off elsewhere. This, of course, is with the exception that the hard median ridge must not be pressed upon

unduly by the plate, and it is best not to scrape the cast at this point when the ridge is included in the outline.

It is the custom of some to raise a well-defined bead around the periphery of the plate. For the molded bases this is done by forming a groove in the cast with a spoon-shaped excavator just within the line marking the plate outline after the method of Dr. W. Storer How.[1] This cannot be accomplished in a similar manner for a swaged plate, since the plate could not be swaged satisfactorily into a groove of this sort. The same result is obtained by soldering a half-round wire (about gauge 18) to the periphery of the palatal surface of the plate. In either case the bead may be trimmed, if it is found after trial that it presses too hard upon any part of the tissue.

The rationale of the action of this measure in maintaining adhesion is as follows: the plate is drawn into place by pressure, and by the withdrawal of the air beneath its surface through suction produced by the tongue and throat muscles. When all the air has been withdrawn and the plate adheres to the surface, the tissues around the periphery are slightly compressed. As they are elastic and tend to assume their normal position, they follow the margin of the plate, as it is pressed away from them under stress, and thus maintain for a greater time the contact of the margins. In course of time under the continued pressure of the margins, the tissue underlying them becomes absorbed, and this elasticity is lost, but the plate margins are then slightly imbedded in the membrane and the ingress of air is more difficult. It must be understood that the plate should press but slightly more around its periphery than elsewhere, and it is not desired to make such alterations in the cast that the plate covering the other portions of the mouth is held off by the contact of its periphery. This would make a vacuum-chamber of the whole plate, a result not to be desired.

The adhesion between a plate and the mucous membrane would be a comparatively simple matter if they were two flat and unyielding surfaces. As it is, the surfaces are irregular, and one, that of the mucous membrane, offers varying resistance to pressure over the different portions of its surface. This, of course, is due to both the density of the membrane and to the amount of tissue intervening between it and the bone. The skeletal foundation is hard and resistant, but the membrane varies normally in density, and in abnormal conditions this variation is even more striking.

In a vast majority of mouths the median line of the upper jaw presents a hard ridge, which is due to the close adhesion of the overlying tissue to the suture between the two maxillary bones, which extends some distance forward as shown in Fig. 364, A. The alveolar ridge is normally much less resistant and its soft tissues are less adherent to the bone. On each side of the median suture the areas which occupy the posterior half of the vault are softer than any other portions of the jaw. This distribution of the resistance of the tissues which is typical of that found in most

[1] The Dental Cosmos Vol. xiv., p. 785.

cases, is often varied, and it will be seen that there is never an equal resistance to the pressure exerted upon a plate over the whole area covered by it, even in mouths which are most favorable for the use of a plate denture.

In about one per cent. of upper jaws there is a fissure instead of a ridge along the median line and in others this part of the mouth is the seat of a hard bony elevation.[1]

While the whole area covered by the plate is more or less compressible, the soft underlying areas are the most so, and it will be noted that when pressure is applied to a plate made over an unaltered cast and accurately fitting the surface, it will bear harder upon the inelastic areas and may rock upon them. Thus pressure applied alternately upon the plate at the sites of the molar and bicuspid teeth will cause it to rock upon the hard median ridge, and if the tissues on one side are compressed until the other side is detached from the membrane, the plate will drop. It is evident that this should be prevented if possible.

Fig. 365

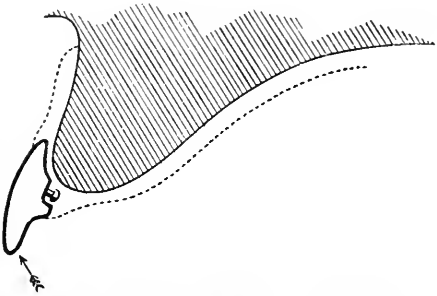


Diagram illustrating leverage upon incisors.

Fig. 366

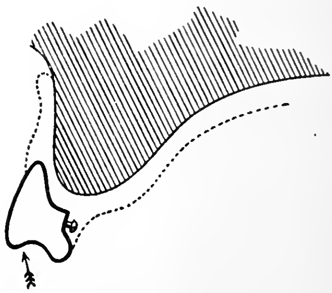


Diagram illustrating leverage upon molar.

Let us consider the direction of the force usually applied to an upper denture and those forces which tend to displace it. During the use of the plate the force of mastication is applied to it along the arch of the teeth, and, as these are approximately over the alveolar ridge or to its labial or buccal side, the ridge itself is the portion of the jaw which receives the pressure of mastication. If the force was applied to the plate along the whole line of the teeth uniformly at all times, as it is when the teeth are in close occlusion, the plate would be firmly pressed into place. But it constantly varies in distribution, amount, and direction, according to the position of the food between the teeth. The pressure received upon the incisors tends by leverage over the process in front to displace the rear of the plate (Fig. 365), while that upon the molars and bicuspids, tends to depress the opposite side by leverage. (Fig. 366.) It is evident that an advantage would be gained if the tissues were uniformly compressible, but this condition never exists. However, if the pressure of the plate upon the hard areas is relieved, and it is not permitted to bear upon them under force until the soft tissues have been compressed into

[1] L. P. Haskell. Items of Interest.

a like resistance, the same object will be accomplished. It is possible to construct a plate which will do this.

The most satisfactory way to effect this result is by making additions at the site of the hard areas to the cast upon which the plate is to be made. A cast made from a plaster impression, which accurately represents the hard and soft areas alike, no compression of the latter having occurred in securing the impression, is compared with the mouth, and the hard areas having been located by a careful digital examination, are relieved on the cast by additions to its surface. When the plate is to be made directly upon the cast, as in vulcanite work, the additions may be most exactly made of layers of tin foil No. 60, cut to size, and laid on to the necessary thickness, usually about three layers being required. These are made to adhere with liquid

FIG. 367

Very flat upper jaw in which plate retention is difficult.

silex. On a cast to be used as a model for a die, wax may be used for this purpose. The standard of compressibility ought to be the normal alveolar ridge in which the tissues are healthy and supported by bone. The hardest areas are to be covered most thickly, that along the median line in an upper jaw being usually the one requiring most attention Bony tuberosities in the median line, as in Fig. 364, B, or those located elsewhere should always be relieved in this way. Some operators prefer to accomplish this end by scraping from the impression at these points, but this does not seem so desirable a procedure, for the reason that it is more difficult to judge of the amount taken from a surface than of that added to a surface, particularly, inasmuch as in the method above described, the thickness of the additions may be always measured.

As there are areas harder than our standard of compressibility, so there are areas softer, but these do not concern us except as they are located at places at which the force of mastication is received. The soft area in the posterior third of the vault on either side of median line does not need any compression by the ordinary plate, although the contact of the edge of the plate therewith should be accentuated.

The alveolar ridge itself is quite soft in some cases, the tissues being spongy and flabby and easily compressible. (Fig. 367). This condition frequently results where the teeth have been lost through pyorrhœa alveolaris, the alveolar process having been considerably absorbed before the teeth are finally lost, leaving a very low ridge covered with a thick mass of soft tissue. This condition of softness is also frequently met with in the anterior portion of the upper jaw, where absorption of the alveolus under a plate denture has been caused by the impact of the natural lower front teeth, the lower molars and bicuspids having been lost and the whole work of mastication thrown upon the anterior teeth and the plate.

It is evident that it is a serious disadvantage to have soft compressible tissues underlying the plate at the very position at which the force of mastication is received, and it is in these cases that it is most difficult to obtain firm retention. The soft tissues yield under pressure, permitting the plate to bear upon the harder portions of the vault with a consequent tilting and dropping.

The measures usually employed to combat this condition are the alteration of the face of a cast which accurately represents the hard and soft tissues in their normal relation, or the taking of an impression of the jaw with some material requiring force in its application which shall compress the soft tissues and thus yield a cast with these tissues compressed as they should be under the plate. In the first of these measures the cast is scraped or carved at portions corresponding to the soft areas with a view to representing them as compressed under the plate. This requires much judgment, but with care a satisfactory result may be obtained in cases in which only the alveolar ridge or certain parts of it are soft. The cast is compared to the tissues and the carving done only after a careful estimate of the amount to be removed.

The methods of taking the impression to obtain a cast representing the soft tissues compressed are described in Chapter VII. It must be remembered that in addition to compressing the soft structures of the ridge, there is danger of also displacing them, and this must be guarded against, or must be remedied by an alteration of the cast. The soft gum tissue is pressed outward as the impression material is carried home, and the cast must be slightly scraped on the buccal or labial aspect of this soft portion of the ridge. Each of these measures is open to the objection of inaccuracy, but a full recognition of the danger which might result from improper alteration of the cast and a careful examination of the mouth in comparison with the cast and the making of alterations to accord therewith, will sometimes warrant the procedure. It is seldom possible to depend upon this measure as the only one to promote the retention of the denture, and it must be supplemented in most instances by the addition of a vacuum-chamber, but in cases of this type the retention is so difficult that advantage should be taken of every means to promote it.

It has been recommended in very difficult cases of this character, in which the whole alveolar ridge is covered with a pendulous mass of

soft tissue, that this be removed surgically under cocaine anæsthesia. This course is the indication where adhesion cannot be obtained without it, and it may be said that the adjustment of the plate will in a large number of cases be simplified by such an operation.

ATMOSPHERIC PRESSURE.

Atmospheric pressure is utilized in the retention of upper plate dentures by the partial exhaustion of the air from a space made for this purpose in the portion of the plate in relation with the mucous membrane. This space is known as the vacuum-chamber. The principle has been in use in dentistry for a long period of time, the first recorded instance of its use in the United States being that of W. H. Gilbert, a confectioner of Hartford, Conn., in 1840. A vacuum-chamber of somewhat different form was patented by Dr. John A. Cleveland of Charleston, S. C., in 1850.

The partial exhaustion of the air from the vacuum-chamber causes the pressure of the atmosphere upon the lingual surface of the plate to sustain it *in situ* upon the jaw. The air is withdrawn from the cavity by the patient by the use of the tongue and throat muscles. A partial vacuum is created in the portion of the mouth just back of the plate and the air is drawn out from beneath it. It is estimated that with the greatest exhaustion of air which it is possible to obtain in a vacuum-chamber three-quarters of an inch square in area, the sustaining force is equivalent to about two and one-half pounds pressure. The vacuum can never, of course, be perfect and it is believed that in a large majority of cases the air in the chamber is only very slightly rarefied.

The use of the vacuum-chamber principle has been the subject of considerable discussion in dentistry, some practitioners having great faith in its permanent utility, whereas others believe that its use is but temporary and uncertain, and consider its attendant disadvantages to greatly outweigh its usefulness. It is argued by the opponents of the principle that in course of time the mucous membrane is drawn into the depression in the plate, thus wholly or partially obliterating it, and in consequence destroying the utility of the device. They also argue that the irritation of the soft tissues caused by the pressure of the edge of the vacuum-chamber and that occurring over the area covered by the chamber, are serious drawbacks to its use.

The advocates of this principle maintain that in the beginning the adhesion of all upper plate dentures is increased by the use of the chamber; that, even if it is of only temporary utility, the stability of the denture thus acquired tides the patient over the period in which he or she is getting accustomed to the fixture. They also argue that, despite the drawing of the mucous membrane into the space, this cavity is never completely filled up, and it is always possible to get some pressure from the atmosphere in consequence. They further add that a space located over the areas ordinarily hard in most mouths produces a relief of the pressure of the plate at these points.

Dr. L. P. Haskell, of Chicago, lends the force of his opinion against the employment of the vacuum-chamber, believing that this device is never necessary, and that just as firm retention can be obtained by a modification of the cast to relieve the pressure upon the hard areas. Dr. Haskell's vast experience entitles his view to the most profound respect.

The vacuum-chamber has become too well-established a principle in dentistry to believe that it will ever be entirely abandoned. It probably has a certain field of usefulness and this is gauged by a balancing of its evident advantages and disadvantages in favor of the former. To obtain the most satisfactory results from its use, careful attention must be paid to the detail of its form and location, and to the avoidance of all measures which tend to emphasize its attendant disadvantages.

The following method of its location is quoted from Burchard: "The slight movement usual with a plate during mastication tends to separate it from the mucous membrane and permit the access of air to its under surface.

"The line of least movement, as the movement is lateral, a rocking from side to side, is along the median line of the vault; and, as the concavity of the hard palate is usually of an irregular vault form, the point of least movement is near its apex. If the movement does not extend to an edge of the chamber, the stability of the plate is not materially affected, but when one of these edges loses its contact, air enters the chamber and adhesion is destroyed.

"The more closely the edges of the chamber approximate this line the less tendency to disturbance there is, so that comparatively narrow chambers are to be preferred; but the depression should be of sufficient size to not materially lessen the effects of a partial vacuum. Naturally the chamber should be in the area of greatest stability, that of least movement. This area will be found around and about the centre of gravity, and in shape resembling the outlines of the dental arch."

There should be a general correspondence in the size of the vacuum-chamber, and the palatal vault and its outline should carefully follow the general outline of the alveolar ridge. It is desirable as far as possible that the distal edge shall not be laid down in very soft tissue, nor should the anterior edges impinge forcibly upon the rugæ. Fig. 368 illustrates how the form of the vacuum-chamber should correspond to that of the alveolar ridge.

The vacuum-chamber should inclose within its area any hard bony elevation which may be found along the median line of the vault, provided this would not carry the edges of the chamber too close to the posterior margin of the plate, or make the chamber unduly large. Where a chamber is to be used in a mouth with a hard median ridge, the form illustrated in Fig. 369, B, is recommended by many practitioners. The edges of such a chamber are nearest to the line of least movement of the plate, and the hard median ridge is relieved.

In order to be effective the edges should be square but not sharp. Unless there is a positive contact between them and the mucous mem-

brane, the air will readily obtain ingress into the partially exhausted chamber. On the other hand, they should not be so sharp or prominent as to cause irritation of the membrane from pressure. The sides

Fig. 368

Casts with plate outline and form of vacuum-chamber marked upon them.

of the chamber should extend in lines perpendicular to the tissue upon which the edges rest.

The most serious evil consequences follow the use of chambers which

Fig. 369

A B

A. Vacuum-chamber form fixed in position upon upper cast. B. Long vacuum-chamber form for use in mouth with long hard median ridge.

are too deep or too large. It has been found by experience that in the softest mouths the air chamber should be slightly deeper than those in mouths with firm and resistant tissue. The vacuum-chamber for the soft mouth should not be approximately thicker than No. 14 (B and

S gauge), while that for a hard mouth should not exceed gauge 16 in thickness.

The vacuum-chamber will be found useful in all cases in which the anterior alveolar ridge is very soft without a corresponding softness of the palatal vault and distal portions of the ridge. It may be used to advantage in very flat mouths of all sorts. It should be used in all temporary plates where the labial portion of the plate is omitted, the artificial teeth resting directly upon the gum. It is also of service in the retention of all partial upper dentures not held in place by means of clasps.

To form the chamber in a vulcanite plate any vacuum-chamber form, cut out of chamber-metal, may be applied to the cast. Chamber-metal consists of a sheet of lead with tin foil on either side; thus it has the softness and pliability of lead, while its surface is protected from the action of sulfur in vulcanizing by the coating of tin. Having been cut to proper shape the form is burnished to the surface of the cast and held in place by three pins inserted, one at its apex and one at each of its distal corners. In the preparation of the cast as a model for a die, the air-chamber form is put in of wax. The ordinary base-plate wax as supplied by the manufacturers is thick enough for the shallowest air-chamber, while the thickest requires an addition of about half a layer. This is pressed into place and made to adhere by means of melted wax. The point of juncture of the periphery of the vacuum-chamber form and the cast should be so distinct, that, when the plate is produced, this edge representing the edge of the vacuum-chamber will be well defined.

Spiral Springs.—Spiral springs are seldom used as a means of maintaining artificial dentures in place at the present time because they have been largely succeeded by the other measures discussed in this chapter. The earliest springs were of whalebone, which were followed by those of steel, and finally they were made of gold. La Forge devised the coiled spring which is the most desirable type for use. They are open to the serious objection that it is almost impossible to keep them clean, and they are generally productive of an irritation of the adjacent soft tissues of the cheeks. There remain, however, a few cases in which other means of retention are inapplicable, and in which spiral springs must be used. These are chiefly cases in which through disease or surgical operations the form of the jaw is so altered that any sort of adhesion is impossible. There are also a few cases of extremely flat mouths or greatly contracted jaws in which the use of spiral springs is necessary.

Care should be taken that their point of attachment is correctly located or they will have a tendency, when the mouth is open, to displace the dentures upon their base or even to protrude them through the lips. These points must be ascertained by trial, the usual point in the upper jaw being opposite the second bicuspid and in the lower jaw between the first molar and the second bicuspid. These points of attachment should be at least seven-eighths of an inch apart in a vertical direction. The spring should be two inches long. The detail of the construction of the

spiral springs and of their attachment is given in former editions of this book and many other older text-books. Their present infrequent use renders a description of their mode of construction unnecessary here.

THE RETENTION OF FULL LOWER DENTURES.

Full lower dentures are maintained *in situ* by their weight and by adhesion. The latter is not of great value in a majority of cases, but acts to a greater or less extent in all. The former is the most important of the active forces of retention, but, as in the upper jaw, the plate must be freed as far as possible from all displacing influences due to faulty articulation and incorrect plate outline. Lower plates are more subject to displacement through the movement of adjacent tissues than are upper plates, and especial care should be devoted to establishing correct outlines for them.

Full lower dentures are the most difficult of all types of dentures for the patient to learn to use, as they have the least mechanical aid to retention of all plates. They are chiefly held in place by the tongue, cheek, and lip muscles, and every measure tending to assist the patient in acquiring facility in using them should be carried out.

Plate Outline for Full Lower Dentures.—In making the plate outline for a full lower denture the same general principle of avoidance of movable tissue, as obtained in the upper jaw, is to be followed. The muscular structures attached to the mandible around the periphery of the proposed plate are located at a level relatively higher than in the upper jaw. The tissues attached to the labial and buccal surfaces of the mandible are placed at a higher level than those attached to its lingual aspect. The plate outline should, therefore, be sufficiently above the point of reflection of the mucous membrane to avoid any possible movement transmitted through this tissue. The muscular structures to be avoided are the attachment of the levator labii inferioris, the depressor anguli oris, the buccinator, and the muscles of the floor of the mouth. The frænum of the tongue must be given full play, and it is desirable to avoid the plicæ of mucous membrane around the external border of the plate, those most commonly found existing opposite the canine and bicuspid teeth. The outline for a typical case is shown in Fig. 370, A, while that for a case in which there has been great resorption of the process is shown in Fig. 370, B.

The plate outline for the full lower denture should be carefully tested when the bite is taken, by requesting the patient to touch the roof of the mouth with the tongue and noting the impingement of the plate upon the tissues on the lingual side of the jaw. A stretching of the lip and cheek tissues upward by means of the thumb and forefinger of one hand, the other hand holding the plate *in situ* to counteract any displacing force which this may develop, will enable the operator to judge of the impingement in these regions. It is impossible in some instances to entirely free the plate from the influences of moving tissue, but the effort should be made to reduce this to the minimum.

Gravity.—The force of gravity is of service in the retention of all lower plates, whether full or partial, being the chief physical force which maintains full lower dentures in place. A recognition of the part played by it in the maintenance of lower dentures has led to the construction of dentures characterized by considerable weight for very flat mouths in which retention is difficult. This object is effected in the use of so-called "weighted rubber" for lower vulcanite dentures and the use of metallic dentures of all forms. Cast metal dentures, cast metal base-plate with vulcanite attachment, swaged metal plates with soldered teeth and with vulcanite attachment, and continuous-gum dentures all possess the advantage of considerable weight.

In the case of a very flat mouth, as is shown in Fig. 370, B, the use of a weighted lower denture is frequently advisable. It must be remembered, however, that the weighting of a denture should not be carried to the point that it is burdensome to the patient. The author has seen a case where extreme weight has so stimulated the absorption of the bone that the mandible had become very thin and dangerously liable to fracture. This contingency must, of course, be avoided. The use of weighted dentures is entirely confined to full cases, as partial lower cases should receive sufficient maintenance from the natural teeth.

FIG. 370

B

A

A. Plate outline for full lower cast with well-defined ridge. B. Plate outline for full lower cast with little ridge.

THE RETENTION OF PARTIAL DENTURES.

Partial Upper Dentures.—These are maintained in place by adhesion, by atmospheric pressure, and by clasps.

Adhesion is of service to a greater or less extent in all cases, but it cannot alone be depended upon: its chief utility is in conjunction with atmospheric pressure. It is manifest that in partial cases the easy access to the palatal surface of the plate which the spaces about the natural teeth afford to the air, makes adhesion a less effective means of retention

than in full cases. When the plate is held in place upon the mucous membrane by atmospheric pressure through a vacuum-cavity or by clasps, adhesion between the plate and the membrane supplements the other retentive means. In most partial upper cases, therefore, where advantage may be taken of the position of the posterior margin of the plate, the contact of this is to be accentuated by scraping the cast as in full upper dentures. This, of course, has to be done advisedly and only in those instances in which the margin rests upon comparatively soft tissue.

Contact of the plate with the natural teeth just above their gingivæ serves to stay it and maintain it in place under the stress of mastication. This contact also serves to prevent the pinching of the membrane between the edges of the plate and the teeth, and should always be established, except those cases in which the insertion and removal of a plate thus made would be prevented because of the contours or inclination of some of the teeth; in such instances the plate must be cut away to permit its easy placement. In this latter class of cases provision must be made to prevent the edge of the plate from sinking into the mucous membrane about the teeth not touched by it, by the employment of lugs attached to the clasps and resting upon the occlusal surface of the teeth as described in Chapter XIV. Advantage is taken of the bracing or staying effect of natural teeth by the use of half-clasps or stays attached to the plate and placed to grasp the tooth or teeth in such a way as to resist the displacing force.

Atmospheric pressure is to be preferred in most cases as the means of retention of partial upper dentures. Exception to this occurs when the configuration of the vault and the consistence of the tissues is unfavorable to this means, and in those cases in which its use would unduly extend a plate carrying only a few teeth. In some cases, as of those supplying the posterior teeth, it is the only available means of retention. Where it is to be employed, the vacuum-chamber is to be located and shaped in accordance with principles already outlined for full dentures.

Clasps as a means of supporting partial upper dentures are discussed later in this chapter, while the details of their construction and mode of attachment are given in the chapter on Swaged Metal Plates.

Plate Outline for Partial Upper Dentures.—In marking the outline for a partial upper case it is advisable to draw it so that the edge of the future plate is just in contact with the cervical margins of the teeth. Teeth which are to be clasped must, of course, have sufficient room about them for the placing of the clasp. Single isolated teeth in the distal part of the mouth are to be included in the plate outline, its buccal edge being made continuous, and the plate carried around them, unless, as the last molars in the series, they would cause the plate to extend too far back. Then the plate abuts upon them, as in the anterior part of the mouth.

At the site of the artificial teeth when they are to rest upon the gum as in the anterior part of the mouth, in cases where little resorption has occurred, the plate is only to extend up to the tooth and not under it, except in partial metal plates where a tongue of the plate should underly

one-half of the portion of the tooth in relation with the process as described in Chapter XIV. In the distal part of the mouth where the teeth are not so visible in the movements of the lips, the plate should extend up as high on the outside of the process as the movable tissues will permit, the same principles obtaining as for full dentures. It is usual, when the teeth back of the canine are to be supplied, to permit the first bicuspid to rest upon the gum, the buccal margin of the plate ascending from the second bicuspid.

The location of the posterior margin of the plate, which determines its size, is to be settled by the number of the teeth it is to carry, and by the locations of the remaining natural teeth, If the plate is to be retained by atmospheric pressure, the posterior margin must be laid down in comparatively soft tissue, and the plate must be large enough to admit of properly placing the vacuum-chamber. If clasps are the retentive device, the plate area may be markedly decreased, and the reader is referred to Chapter XIV. for a discussion of this feature.

Retention of Partial Lower Dentures.—These are retained in place mainly by gravity and by contact with the remaining natural teeth, usually through the instrumentality of clasps. Lower dentures cover so small a plate area that adhesion plays little part in their retention. Because of their small plate area it is necessary that every measure be taken which will assist in maintaining the plate upon its proper resting-place. This fact, together with that of the known difficulty attending the use of full lower dentures, should indicate the importance of retaining all natural teeth in the lower jaw which might be utilized to stay the plate even for a short period.

A partial lower denture can be advantageously equipped with clasps in nearly every case. These are intended chiefly to maintain it in place upon its supporting base, but occasionally they must be designed to transmit some of the force of mastication to the natural teeth. Thus, for example, a denture supplying all the posterior teeth often exhibits a tendency to move backward in use, and clasps attached to the natural teeth adjoining the vacant spaces on either side should be arranged to prevent this movement. In cases of this kind where a natural second or third molar remains in the mouth, the plate abuts upon this and the backward tendency of the plate is obviated.

Far greater liberty is permissible in the way of contact of the plate and clasps with the natural teeth in the lower jaw than in the upper jaw. In the former case the fact that the teeth are bathed to a greater extent in the saliva, which by reason of gravity is more plentiful about them and thus the acid products of fermentation and bacterial activity are more quickly neutralized, renders this contact less harmful to the teeth.

Plate Outline for Partial Lower Dentures.—For partial lower plates the margin of the denture is to be determined according to the following method: the plate should rest upon the remaining natural teeth for the maintenance and slight additional support which is thereby gained. In the front of the mouth the plate outline is to be marked half way up

the lingual surfaces of the teeth, the remainder of the periphery of the plate being determined as for full dentures by the location of the movable tissue. A single isolated tooth perpendicular to the ridge is to be included in the plate outline, the buccal margins being continuous and an opening made in the plate to receive the tooth.

The high attachment of the tissue of the cheeks upon the buccal surface of the mandible makes it usually necessary to have the buccal margin of the plate relieved at this point. Experience has demonstrated that this edge of a plate made upon an unaltered cast has a tendency to bury itself in the tissue. It is, therefore, advisable in many

FIG. 371

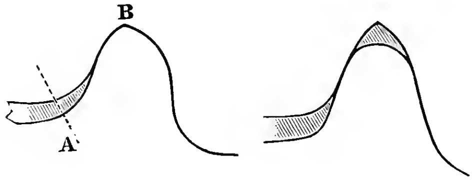


Diagram illustrating addition to lower cast.

full lower cases and in all partial lower cases to make an addition to the cast along this line as represented in Fig. 371.

Where the summit of the alveolar ridge is represented as being sharp and thin, it is advisable to relieve the plate somewhat at this point by making an addition to the cast. This permits the plate to have its point of bearing on the sides of the ridge instead of upon its summit. Fig. 371 illustrates the manner of making this alteration.

CLASPS.

"Clasps[1] are metallic bands partially encircling the crowns of natural teeth, and serving as a means for the retention of artificial dentures. The employment of the device is prompted by necessity, and not by choice. In upper plates they are employed where the vacuum-chamber is found to be insufficient to retain a denture in position, where the configuration of the vault renders the chamber inapplicable, or where the positions of the replaced teeth render the covering of the vault with a large plate unwarrantable. They are attached to partial lower dentures to prevent displacement by the movements of the tongue, cheeks, and lips, and by the forces to which these pieces are subjected during mastication.

The great advantage of the employment of clasps is an increased stability of the piece, the disadvantage is, if worn long enough, they eventually cause the loss of the crown of the tooth clasped, through chemical solution, and mechanical abrasion. The food-deposits beneath and about the clasp are the seat of lactic fermentation, so that a gradual solution of the crown by lactic acid occurs, if the clasps are not kept in an aseptic condition.

[1] Burchard: American Text-Book of Prosthetic Dentistry, Second Edition.

Not infrequently the teeth are so mechanically strained by the force of mastication transmitted through the clasps, that the retentive apparatus of the teeth succumbs and the teeth are dislodged. The latter is a more serious consideration than the loss of a crown; an artificial substitute for the latter may be provided and serve for clasping, but loosened teeth are the *bete noir* of dentistry. This danger is lessened by accuracy of adaptation of the plate, and by having the clasps of sufficient elasticity to yield to stress and diminish the strain on the teeth.

Clasps properly adapted serve but to stay a plate, not to support it. The support should be derived from uniform pressure upon the soft tissues; the clasps are an adjunct preventing displacement. The violation of this principle is responsible for many of the ills attributed to the wearing of clasps.

In selecting teeth to be clasped, where a selection is possible, they should be chosen with a regard to their form, the position and condition of the tissues of the teeth, and the surrounding parts."

In the upper jaw the most satisfactory tooth to afford attachment for a clasp is the first molar. Its location, strength, and shape are especially favorable to its use for this purpose. Next in order come the second bicuspid, second molar, and first bicuspid. The disadvantageous position of the third molar, its shortness, and irregular shape render it seldom of use for clasping, though sometimes it may be the only dependency and must be used. Only in extreme cases should the upper canine be clasped, and even less frequently the central and lateral incisors. These teeth are all poorly shaped for clasping, besides being weaker than the distal teeth, and in addition the displayal of a gold clasp about them is objectionable. When it is necessary to clasp the canine, the clasp should be shaped and located to appear as a cervical gold-filling in the tooth.

In the lower jaw the teeth most commonly used for clasp purposes are the bicuspids, as these frequently adjoin the vacant spaces to be supplied by the plate and are most satisfactory for this purpose. The first molar has the advantage of strength and favorable shape, but is less frequently used because its presence in the mouth either indicates a case in which the molars back of it alone are missing—a case in fact in which it is doubtful if the advantage gained by supplying these few teeth compensates for the trouble of wearing it, experience proving such plates unsatisfactory—or it may mean a case with teeth anterior to the first molar missing in which bridgework would be greatly preferred.

If possible two teeth on opposite sides of the mouth should always be selected for clasping, so located that a line drawn from one to the other would pass through the centre of the plate, if it be an upper denture, and if it be a lower plate, they should be located to be of the greatest mechanical support. In difficult lower cases even a single central incisor may be clasped to advantage, thus serving to hold the plate on the alveolar ridge, and hence greatly aiding the patient in acquiring the use of the denture.

CHAPTER XII.

THE SELECTION, ARRANGEMENT, AND ARTICULATION OF ARTIFICIAL TEETH.

By Charles R. Turner, D.D.S., M.D.

In a general way it may be said that the objects of artificial dentures are the restoration of the impaired functions and the altered facial appearance which have ensued from the loss of the natural teeth. Artificial dentures should restore any lost parts of the mechanism concerned in the preparation of food for subsequent stages in its digestion, or should establish a satisfactory means for the execution of this function. If the normal voice and articulate speech have been impaired by the loss of the teeth, the dentures should restore these by providing a substitute for the lost tissues concerned in the sound production, and they should impose no impediment to the proper exercise of these functions. They should restore the lost portions of the apparatus by which the expressive movements of the face are produced, and not interfere with the normal operation of these activities; and finally, they should restore the facial contours and the fixed expression of the face, and provide such substitutes for the missing tissues in those portions of the mouth which are exposed to view in laughter or speech, as shall be in harmony and accord with the other features of the face. In addition, they must be constructed with the view of utilizing to the best advantage the materials at command, and in consonance with such sound mechanical principles as will insure the efficiency of the appliance.

To design a denture which shall successfully meet these requirements demands an acquaintance with the normal operation of the impaired functions, a recognition of the alterations which have been produced by the loss of the teeth, and a knowledge of the materials and principles which may be best adapted for the restoration of these functions. Furthermore, the placing of an artificial denture is to be regarded as a rational therapeutic measure, in which the requirements of each individual case are recognized, and the appliance designed and constructed to meet the indications thereof.

Here follows a tabulated list of the ends to be subserved by artificial dentures, together with the factors concerned with promoting these ends.

I. Food preparation	A. Stability of the plate.	1. Physical means of retention. 2. Correct plate outline. 3. Correct articulation of teeth.
	B. Functional efficiency of the teeth.	1. Form. 2. Arrangement.
	C. Mechanical efficiency of plate and teeth.	1. Strength of teeth. 2. Strength of base-plate. 3. Correct relation of teeth to base-plate to resist stress.

- II. Voice and speech.
  - A. Form, position and arrangement of teeth.
  - B. Form and lingual contours of plate.
- III. Expressive movements of face.
  - A. Positions of the teeth.
  - B. Form and labial contours of the plate.
  - C. Relation established between the jaws.
- IV. Facial expression.
  - A. Facial contours.
    - 1. Lips.
    - 2. Cheeks.
    - 3. Relation between jaws.
      - a. Positions of teeth.
      - b. Buccal and labial contours of the plate.
  - B. Teeth as features of the face.
    - 1. Color.
    - 2. Form.
    - 3. Relative positions.
    - 4. Gums.

These factors will be discussed in detail from the standpoint of the principles underlying their correct adaptation to the individual case. They will, however, be considered under headings somewhat different from the above, since many of these factors are concerned with both the utilitarian and cosmetic purposes of the plate, and besides avoiding unnecessary repetition, the method selected seems to afford the simplest means of elucidating the subject.

Fig. 372

Casts arranged upon articulator, with bite-plates removed.

The design of artificial dentures to effect the various purposes above outlined, includes the selection, arrangement, and articulation of the teeth, and the arrangement of the plate form and contours. The technique of denture construction using the various bases will be described in succeeding chapters.

Many of the data which are to be used in the process have been obtained from the patient at the time the bite is taken, and it is supposed that the casts have been mounted properly upon the articulator, and that the bite-plates have been laid aside for reference. (Fig. 372.)

THE SELECTION OF ARTIFICIAL TEETH.

Suitable artificial teeth for use in the vast majority of cases which the prosthetist is called upon to treat may be obtained by a judicious selection from the stock of the manufacturers, which it has been said in Chapter III., is sufficiently comprehensive to meet most of the needs of the present day. The teeth selected will, in most instances, require some modification on the part of the dentist to fit them for the case in hand. Details of these procedures will be discussed subsequently in this chapter, and it is sufficient to say here that the alterations in the teeth are with a view of adapting them to meet the peculiarities of the individual case.

The considerations which determine the choice in the selection of artificial teeth for a given case are, first, anatomical: that they shall have the appearance required of substitutes for the natural teeth, and the form demanded by their proposed functional activities; and secondly, mechanical: that they may be adapted to the base upon which they are to be mounted, and satisfy such other mechanical demands as are incident to the shape and relation of the jaws in the individual case.

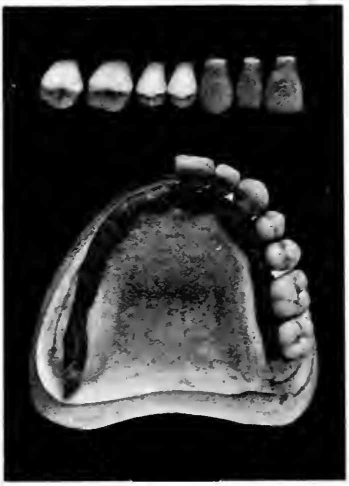
The physical characters of the teeth relating to their appearance are determined in edentulous cases by the consideration of temperament. This requires a diagnosis of the predominating temperamental type or combination of types existent in the individual. A careful study of the physical attributes associated with the basal temperamental types and of their combinations in the excellent tables of Dr. A. H. Thompson, is urged upon the student, and a thorough acquaintance with the details of the physical characters of these types is necessary. In general it may be said that, in the matter of color of the artificial teeth, the complexion of the individual and the coloring of other pigmented tissues of the body, are the guides which may be most safely used, and that, as for the dimensional characteristics of the teeth, the general physique and, in particular, the physical characteristics of the head and face, are of best service for their determination. In addition to this, something more will be needed in the way of an appreciation of form and color, which will enable the dentist to produce a harmonious result. The existence of this harmony in nature, for the most part, is the basis upon which the restorations are made. This harmony is not, however, universal, for there are occasional exceptions to the principles which have long been established. There are people who have teeth apparently too small and of a color too light, but they are always the exception, and for this reason, attract an attention, which it is desired the patient with the prosthetic appliance shall avoid.

From a cosmetic standpoint the end to be aimed at first is the re-establishment of the personal appearance of the individual. This is not always possible, because the data which are at hand are at best not sufficiently complete. Nor is it in every case advisable, even if it were possible, for instances occur in which the exact reproduction of the conditions which existed before the loss of the teeth would require

the imitation of a disfiguring defect. In such cases it may be said that the reproduction of a condition known to exist before the teeth were lost, which condition amounted to a deformity, was in poor waste, or was greatly lacking in æsthetic effect, is only justifiable when there are strong reasons for perpetuating it as a means for preserving physical identity.

1. The Size and Form of the Teeth.—In the selection of teeth for an edentulous case, it is desirable to know the size and shape of the lost natural teeth for which substitutes are required. This is seldom possible, except in the few cases in which the prosthetist has extracted the natural organs, in which event they should be carefully preserved for guidance in the selection of the artificial teeth. In general other means must be used for determining the size and shape of the artificial teeth.

FIG. 373



Full upper cast, showing the trial of artificial teeth of proper size with second molar reaching center of the maxillary tuberosity.

Because of the resorption of the alveolar process and the consequent diminution in the size of the maxilla, but twenty-eight teeth are used for full artificial dentures, the third molars being omitted. If the full complement of teeth were used, they would either be too small, or if of proper size, could not be correctly arranged in relation to the process. The data which indicate the combined width of the teeth must be obtained from the casts of the mouth. When placed in trial upon the upper cast in that relation to the alveolar ridge which it is proposed they shall occupy, with the centrals on either side of the median line, the distal side of the second molar should rest upon the centre of the maxillary tuberosity. (Fig. 373.) In cases of extreme resorption of the alveolar ridge, the cast alone does not furnish all the desired information, but for the most part it is usual to judge of the width of the teeth by their relation to the length of the upper alveolar ridge.

As obtained in full sets from the manufacturers, the sizes of the individual teeth of a series are intended to be correctly proportioned. The "fronts," or six anterior teeth, and the "backs" are matched to have the same general proportion and may be fairly trusted for this. Cases sometimes present, however, for which the size of the "backs" may be increased to advantage, because the canine of the series comes only to about the position of the canine eminence, while the backs do not reach the tuberosity. Minor differences in the proportion of the back teeth met with in the natural series need not be imitated. Variations in the proportionate size of the six anterior teeth may, however, be imitated to great advantage, and the selection of larger centrals or canines for use in appropriate cases will often be attended with happy results. This will be mentioned later.

Having decided upon the proper width for the upper teeth, their length is next to be determined, and this is largely decided by the temperamental indications of the patient, together with a purely physical factor, namely, the position of the high lip line. This latter landmark, it will be remembered, indicates the highest point to which the lip is elevated in smiling and laughter, and it is desirable to have the portion of the artificial denture which is displayed by these acts represented by teeth, unless this would make them too long. However, the correct proportion between the length of the teeth and their already determined width must be preserved to accord with the predominating temperamental indication of the patient, and in no case should this consideration be sacrificed. The mobility of the upper lip varies in individuals and in some it may be elevated so high as to display a good deal of the adjoining gum and process. Therefore, this space cannot always be filled in with the artificial teeth, and in cases of a very high lip line, the use of gum-section teeth is sometimes justifiable. This will also be discussed later. The distance between the high lip line and the lower edge of the bite-plate which corresponds to the proposed position of the cutting edges of the anterior teeth, should be the trial length of the artificial teeth, the correct proportioning of this length to the width in accordance with the temperamental indication of the patient should be the final deciding factor as to this dimension.

The general form of the teeth is, of course, determined by their width and length, but their appearance is also affected by the character of their outline and their surface. These are matters which are wholly determined by temperamental indications for a tabulated list of which the reader is referred to pages 259–262, in Chapter V. Except in rare instances in which mechanical advantage is obtained by a different form of tooth, as of those of protruding jaws, the surface contours and outlines of the teeth should correspond with the temperamental indications of the patient. The rounded form of the sanguine temperament should be used for that temperament, while the flat faced angular tooth with constricted neck should be used for the nervous

(see Fig. 374). The manufacturers supply a sufficient variety of molds for satisfactory selection, but they also provide teeth made of the shade of one temperament and of the characteristic color of another. These are made largely for commercial reasons to supply a demand which arises without a just appreciation of the harmony desirable in such matters and their use should be avoided.

2. The Color of the Teeth.—The most difficult physical characteristic of the artificial teeth to determine is their color. In edentulous cases as has already been indicated, this must be selected upon a judgment based upon other physical characteristics of the patient. A few remarks upon the color of the natural teeth may not be out of place.

Fig. 374

A C

B D

Four basal temperamental types of artificial teeth: A, bilious; B, nervous; C, sanguine; D, lymphatic.

The color of teeth is, in general, due to two things—the intrinsic color of the enamel and dentine, and their proportion and distribution in a given tooth. The intrinsic color of the enamel and dentine is in accord with that of the other pigmented tissues of the body. It harmonizes with the color of the hair, the eyes, and in particular with the color of the skin. This latter is of the greatest importance in determining the color of teeth. Ivy[1] has said that the complexion is of great importance in deciding the color of artificial teeth. Joseph Head[2] has stated his belief that the fundamental color of the skin over parts of the body protected from the sun, and that of the teeth is the same, and that if the pink element in the former due to the presence of the blood were removed by pressure upon the part, the color of the skin thus observed should be the fundamental color of the artificial teeth. The author is not wholly prepared to accept this view, but has observed instances in which it was fairly accurate.

The state of organization of the teeth has been supposed to partly account for the color. It is certain that the greater translucency of

[1] American System of Dentistry. Vol. ii., p. 1034.

[2] In private conversation.

the enamel in the nervous temperament is a result of its high state of organization, and accounts in part for the blue cutting edge characteristic of these teeth, while the opaque enamel of the teeth of the lymphatic temperament is commonly observed to be of poorer structure.

The proportion between the enamel and dentine also is related to the color of the teeth. In the typical lymphatic teeth, for instance, the opacity of the enamel and the fact that it is generously backed up with dentine partly account for their color, while in the thin teeth of the nervous temperament, the enamel plates at the cutting edges of the incisors enclose little or no dentine, permit the light to be carried through, and appear blue at this point. Furthermore, the commonly observed yellow color at the neck of incisor teeth is due to the thinness of the enamel which permits the yellow color characteristic of dentine to show through.

As age advances there is a deepening in the shade of the tooth which is due to a molecular change in its tissues, and teeth are a shade or so darker in middle or late life than they were in early years.

The fact has been brought out by E. A. Royce[1] after a careful examination of a large number of natural teeth that the individual members of any given natural set vary much in shade. He says, "In our study of this subject we must have some standard by which to measure the shade of each tooth, and for this standard the upper central incisors of the denture under consideration were always taken. Some means being necessary to convey to you the different shades of the teeth in the mouth, I selected 0, or zero, to represent the shade of the central incisors, using numerals to express the other shades—the higher the numeral the darker being the shade." * * "The upper central incisors are the lightest, the laterals are darker, and the canines are darker still. The first bicuspids are generally lighter than the canines, and the second bicuspids lighter than the first. The first molars generally vary but a shade or so from the second bicuspids."

The general color of the artificial teeth should be selected to accord with the temperamental indication of the patient according to the tables on pages 259–262. This should be modified in shade by the age of the patient, an individual past middle life requiring teeth usually as much as two shades (of the manufacturer's shade-guide) darker than at an early period in life. For reasons of convenience the shade of the teeth should be selected at the time the bite is taken. The trial shade should be actually tested under the lips, because, from the shadow cast by the latter, the teeth will appear lighter in the mouth. The same shade-guide used in the patient's mouth should be used, if possible, at the dental depot, because there are many slight variations in teeth said to be of the same commercial shade which are due to details of molding and burning, and these differences exist in the sample teeth of the shade-guide.

A happy effect may usually be produced by the selection of the anterior teeth from different sets, thus breaking up the unnatural uniform-

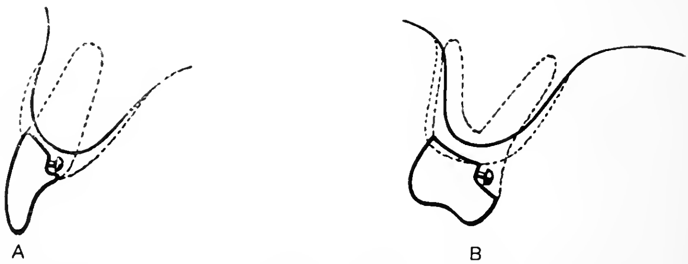
[1] The Dental Review, Vol. xv., pp. 301 and 934

ity in color observed in the stock sets. Slightly darker canines usually give a very natural effect to the teeth, and frequently the use of slightly bluer lateral incisors, and bluer bicuspids will add to this. The different shades recommended by Royce may also be obtained by the use of oil stains, as described on page 429.

We next come to discuss the selection of teeth in order that they may fulfill the mechanical requirements imposed by the base used, the relation of the jaws, and the amount of resorption of the process.

3. The Base.—Artificial teeth are constructed with a means of attachment and a general form suitable to the base upon which they are to be mounted. Vulcanite and celluloid teeth are similar and may be used interchangeably upon the two bases. Plate teeth are suitable for

Fig. 375



A Diagram showing the ideal relation of an artificial incisor to the alveolar process. B Diagram showing the ideal relation of an artificial molar to the alveolar process.

crown and bridge or metal plate work. In England and on the Continent they are used to some extent for vulcanite work, for which purpose they are made with long pins which are bent into a hook for attachment to the base. For cast dentures, where the metal is cast directly about the teeth, vulcanite teeth are used and they are occasionally useful in continuous-gum dentures, although the teeth made especially for this work are the usual indication.

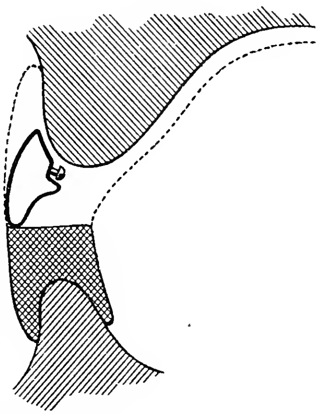
4. The Amount of Resorption of the Alveolar Process and the Distance Between Jaws and their Relation.—In the mounting of the artificial teeth, other things being equal, it is desirable to have their occlusal ends occupy the position with relation to the alveolar ridge which was characteristic of their natural predecessors. The incisors, canines, bicuspids, and molars would be placed, therefore, over the alveolar ridge, in the upper jaw, and slightly to its buccal and labial sides. (Fig. 375.) In the lower jaw the incisors and canines would be slightly to the labial side and over the ridge, while the line of teeth then crosses the ridge, the last molars being somewhat to the lingual side of its summit. This ideal method of placing is by no means always possible, because of the state of resorption of the process and the relation of the jaws. The proper placing of the teeth will be discussed later in this chapter, but inasmuch as they may be selected of such form

as to greatly facilitate this, the mechanical demands upon them must be known at the time they are selected, and the choice made to further this end. There are also mechanical requirements incident to the strain upon the tooth in use, which may be furthered by judicious selection.

The labial surface of the fronts and the buccal and occlusal surfaces of the backs are fashioned to meet anatomical demands; other portions of the teeth are designed, as was seen in Chapter III., to meet the mechanical demands above referred to. As plain rubber teeth are the ones in which this provision is best brought out, they will be used to illustrate the principles.

The anterior teeth have the headed pin which affords attachment to the base-plate, a pin guard, which makes the division between "the bite" and the "shut," and also what is technically called "the ridge lap."

Fig. 376



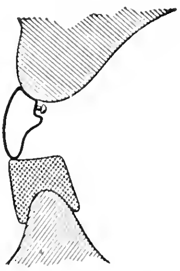
Diagrammatic drawing showing section through upper cast and lower bite-plate, with artificial incisors properly filling in the space. The dotted line indicates the contour of the upper bite-plate.

Other things being equal, it is desirable in full sets to have the pins near the alveolar ridge. The "ridge lap" is intended to be in relation with the alveolar ridge, and "the bite" makes up the other part of the length of the tooth. Long bite teeth, it must be remembered, ase not the strongest type of teeth because of the leverage upon them, the pin being the fulcrum, the length of "the bite" part of the tooth representing the power arm. Long bite teeth are, therefore, not recommended for use in cases demanding great strength in which other types will answer the requirement. In most full cases, however, they may be used with reasonable assurance of sufficient strength.

The upper bite-plate having been removed, the space between the anterior edge of the lower bite-plate and the alveolar ridge is to be filled in with "the bite" of the teeth selected, the remainder of the length of the tooth has to be made up in ridge lap. (Fig. 376.) Thus when there has been little resorption of the process and the jaws are some distance

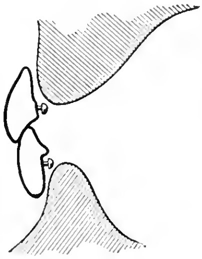
apart, the teeth may rest almost upon the ridge, and a tooth with a short ridge lap is selected. (Fig. 377.) Where the jaws are close together, however, a tooth with long ridge lap must be used, and, of course, of short bite, since in teeth of a given length the ridge lap and bite are usually inversely related. (Fig. 378.) Where there has been much resorption of the process and the teeth are to be mounted almost

Fig. 377



Use of short ridge lap with small amount of resorption of process.

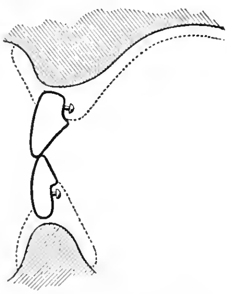
Fig. 378



Use of long ridge lap with a short distance between the jaws.

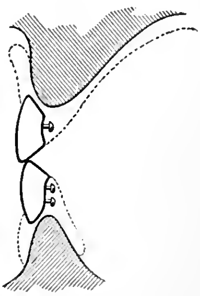
upon the ridge, a short ridge lap is indicated. (Fig. 379.) To avoid the use of a long bite tooth in a given case, a tooth with a long shut may be used, but it must be remembered that the plate must not be made too thick at the portions about the pins, as it may interfere with speech. (Fig. 380.)

Fig. 379



Use of short ridge-lap tooth with much resorption of process, mounting tooth directly over ridge.

Fig. 380



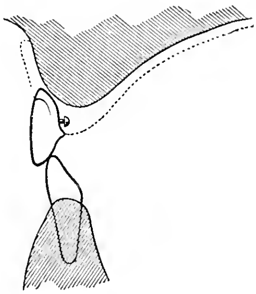
Use of long shut tooth, with short ridge lap, where there is much space between jaws and little resorption of the process.

Where plain teeth are to be mounted directly upon the gum, as in all temporary dentures, a short ridge lap must be used.

When the antero-posterior relation of the jaws is abnormal, as in protruding upper or lower jaw, this condition may be accommodated in the teeth selected. Thus, in a protruding upper jaw, a short ridge lap is indicated for the upper teeth, while in a protruding lower jaw, teeth with a long ridge lap may be used advantageously in most instances.

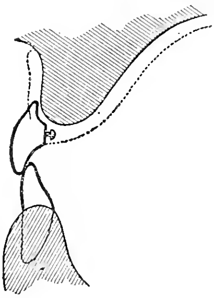
(Fig. 381.) In a protruding upper jaw, too, the use of teeth with a flat face provides a means of making the protusion less apparent, while on the other hand, when the lower jaw is anteriorly placed, so-called "bow-faced" teeth will lessen the apparent protrusion of the lower jaw and often permit a better arrangement of the upper and lower incisors. (Fig. 382.)

Fig. 381



Use of flat-faced tooth for protruding upper jaw.

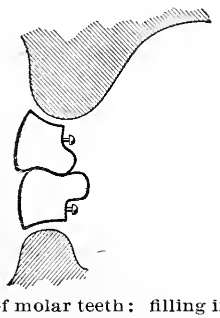
Fig. 382



Use of bow-faced tooth for protruding lower jaw.

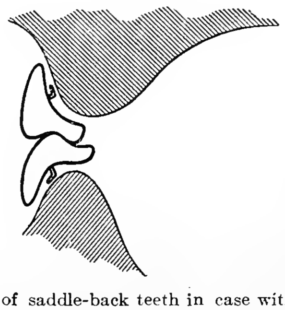
In the bicuspid and molar region, the adjustment of these teeth to the alveolar ridge may be made with greater ease. The use of teeth, as long as the distance between the ridges will permit of their proper placement, is indicated. This brings the tooth closely in relation with the ridge, thereby lessening the amount of base used, and, if the amount of the tooth above the pins is as great as possible, this is an added ad-

Fig. 383



Fitting of molar teeth: filling in space between the ridges.

Fig. 384



Use of saddle-back teeth in case with short distance between ridges.

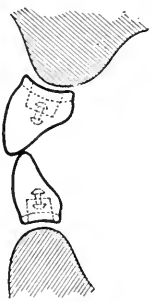
vantage, for in the articulation of these teeth it permits the making of the sulci deeper by grinding. (Fig. 383.) Cases will be met with, however, where the distance between the two alveolar ridges is so short that recourse must be had to so-called "saddle back" teeth, although this is more especially necessary in partial dentures. (Fig. 384.)

The use of countersunk pin teeth is only possible when the distance between the jaws is sufficient to permit them to be placed almost di-

rectly over the ridge, in which instances their anatomical form will be found advantageous. (Fig. 385.) Plate teeth and continuous-gum teeth do not have the divisions of vulcanite teeth above alluded to, except that in the case of the former a general conformation to this plan is made by grinding at the time they are fitted, and they should be selected with this in view.

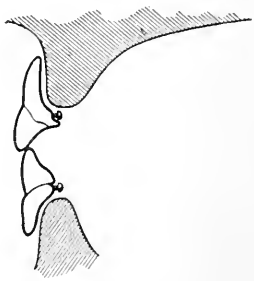
The use of gum section teeth is the indication in some cases, but the number of these instances is small. The fixed relation between the teeth of a block limits their usefulness because there is little or no latitude in their arrangement. They are contraindicated in those cases in which little resorption of the alveolar ridge has taken place for the obvious reason that they would cause too great fulness of the denture at this place. They are used to best advantage in cases in which much of the denture is displayed in laughing, as indicated by the high lip line,

Fig. 385



Countersunk pin teeth set over ridge.

Fig. 386



Gum section filling in space exposed in smiling and laughing.

when the space between it and the lower bite-plate cannot be filled in with a plain tooth without the use of one anatomically too long. (Fig. 386.) They, of course, should be selected as regards their anatomical and mechanical forms by the same indications as prevailed with plain teeth. The natural appearance of the gum portion of the section, an imitation of mucous membrane only equalled by that of continuous-gum work, is the only advantage which they possess.

THE SELECTION OF TEETH FOR PARTIAL DENTURES.

In the choice of teeth for partial dentures the dentist is greatly aided by the remaining natural teeth and in proportion as they are many or few. In the matter of size, form, and color, the artificial teeth should, of course, correspond with those in the mouth as closely as expediency in each case warrants.

In general, the desired color of the artificial teeth may be obtained exactly from those that remain. Difficulty is frequently experienced, however, in exactly matching the distribution of the shades in the artificial teeth to those of the natural, for the reason that natural teeth are

not of uniform shade from cutting edge to gingival margin. This is due to the varying proportions of enamel and dentine, the thinness of the enamel at the neck of the teeth permitting the dentine to give an increasingly yellow cast to the teeth at this point. Artificial teeth of different manufacturers have different proportions of the "point and base" enamels which give color to these regions, and a perfect matching from their stock is not always possible. Here the use of stains according to the method described later in this chapter will be found very useful in obtaining desired results.

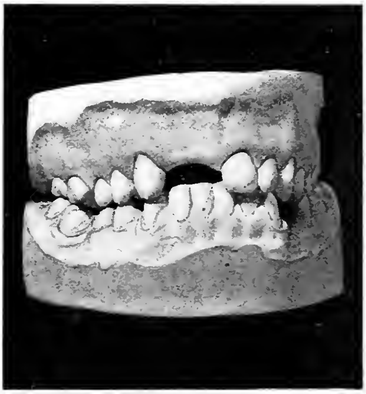
Where an artificial tooth is to be placed between two natural ones of different shades, it is advised that a tooth intermediate in shade between the two natural teeth be selected and darker than the estimated shade rather than lighter, since a tooth a little too dark attracts less attention than one too light.

The size and form of the teeth should accord with those in the mouth. As to the former, it is sometimes justifiable to use teeth a little wider or a little narrower than the teeth they are to replace, when the space between the adjoining teeth has increased or diminished since the loss of the natural teeth. In the front of the mouth where the teeth are visible this must be done with extreme care, and the teeth selected should not be of such difference in size as to attract attention. And in the front of the mouth also where movement of the teeth has produced a

Fig. 387

Partial case requiring plain teeth.

Fig. 388



Partial case requiring gum section teeth.

widening or narrowing of the space, their movement to correct position by orthodontic means is frequently advisable, and the procedure is attended with happy results, because the denture serves as a permanent retaining appliance. The size of the distal teeth and those in the lower jaw in particular, which are not visible during lip movements, may be varied with greater liberty. A common case of this sort is that in which three artificial bicuspids are used distal to the canine, to replace the two bicuspids and a molar, the second molar having moved forward and closed the space: often one bicuspid and a molar are suffi-

cient to fill this gap. It is usual, however, to use an artificial canine tooth back of a natural canine, as the sudden thickening of a plate by the use of a bicuspid is not so comfortable to the tongue.

The amount of resorption of the alveolar ridge is another factor of importance in the selection of teeth for partial cases. The general rule is that where only a small amount of resorption has occurred, the artificial tooth rests upon the natural gum and a plain tooth is used. (Fig. 387.) If, however, the process has resorbed to such an extent that a tooth too long for harmony with the adjacent natural teeth would be necessary, or the gum contours must be restored, a gum tooth appropriate to the case is chosen. (Fig. 388.) The manufacturers supply a variety of gum sections which may be used with much advantage in these cases. The color of the gum should be carefully matched to that of the adjacent tissue.

The length of the bite, or the distance between the jaws, also determines the kind of tooth selected as to bite and ridge lap, according to the general principles already outlined for full dentures.

Short bite teeth are to be preferred in every instance in which they are available, as teeth are subjected to greater strain on a partial than on a full denture, but partial cases exist with marked overbite of the remaining natural teeth and then a long bite tooth is the only one that can be used. Where the overbite is very great, however, it is usually advisable to use a plate tooth, even for vulcanite work, in which latter instance a gold backing is applied, and a tongue-like projection is extended into the plate, making the plate stronger at the point at which strength is needed.

I. THE ARTICULATION OF THE TEETH.

The Arrangement of the Anterior Teeth.

The objects to be subserved in the placement of the anterior teeth are those of incision, of articulate speech, the establishment of correct facial profile and contours by their support of the lips and cheeks, and finally, the securing of their harmonious relationship as a feature of the face. As the appearance of the patient is chiefly affected by the upper anterior teeth, and as these may be arranged first and the distal teeth subsequently placed to accord and properly functionate with them, it is usual to arrange them first. It is supposed that the casts have been mounted upon an articulator capable of individualizing the movements of the mandible, and that the bite-plates have been retained for the data which they furnish in the setting of the teeth.

The requirements imposed upon the anterior teeth by their functional relations in the operation of incision are so closely related to the subject of plate maintenance that they may be considered subsequently when this matter is dealt with. Suffice it here to say that the utilitarian and cosmetic purposes of the denture are often in conflict in the arrangement of these teeth. For the most part it is desirable to consider as of

first importance the requirements of appearance, and then to make such compromise between these demands and those imposed by the incisive function as will subsequently be pointed out as advisable. In the case of patients well past middle life, where the resorption of the alveolar process complicates the placing of the anterior teeth in such a way as to serve both the ends of appearance and those of function, it is wise to sacrifice the former in favor of the latter, because in these instances the correct functioning of the appliance is of the greater importance.

The anterior teeth are the chief ones concerned in the functional relations of articulate speech, but it is commonly true that when their positions satisfactorily answer the other necessary requirements, they usually meet the demands of speech because of the ability of the tongue to adjust itself to various conditions. The function of speech is also largely influenced by the form and contours of the plate, and these several considerations will be discussed later.

The part played by the anterior teeth in the support of the lips in proper profile and contour will also be discussed under a subsequent heading.

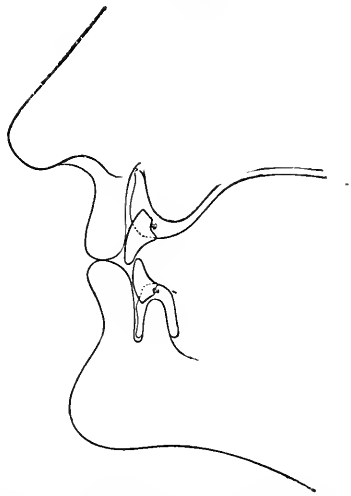
It is here purposed to take up, first, considerations relative to the appearance of the anterior teeth as a feature of the face. In order to serve as a feature of the face which thoroughly harmonizes with its environment, it may be said, in general, that the anterior teeth should answer the requirements imposed by the temperamental relationship, and should also accord with the age indications of the case. Inasmuch as the data are lacking which would permit an exact reproduction of the appearance of the natural teeth, the object sought should be to have the artificial teeth appear as a natural endowment of the individual, and exhibit evidences of the changes which would have been present upon the natural teeth at the age of the individual. In addition to these requirements, their appearance must possess an intrinsic artistic value. It would not be enough, for instance, to exactly reproduce in the mouth of a patient the characteristics of the natural teeth of another individual, selected at random, though of similar age and temperament. Such a denture would be natural looking, but it might not also be pleasing to the eye. Natural dentures to be copied should have some artistic value, since in the mouth of an edentulous patient a denture may be placed which accords with the age and temperament indications and also has intrinsic artistic worth.

In the arrangement of the artificial teeth, the purpose is to imitate the original endowment of the individual and to imitate the effects produced by the causes which have operated in the environment of the teeth, and these effects must be copied from the observed effects existing in mouths under similar conditions. We shall now take up in detail the factors which contributed to these several ends. The articulated casts and the bite-plates furnish the data for the following items: the inclination of the teeth, the median line, the position of the cutting edge of the teeth, the curve of the arch, the support of the lips, and the antero-posterior relation of the jaw.

1. The Color, Size and Form of the Individual Teeth.—These have been determined by their selection, as already described.

2. The Relation to the Lips.—The proper relation of the teeth to the lips largely contributes to the beauty of the teeth as a feature of the face. The most beautiful cases are those in which the cutting edges of the upper anterior teeth project but very slightly below the lower margin of the upper lip. (Fig. 389.) In some cases the natural teeth have

FIG. 389



Drawing showing ideal relation of artificial teeth to the lips.

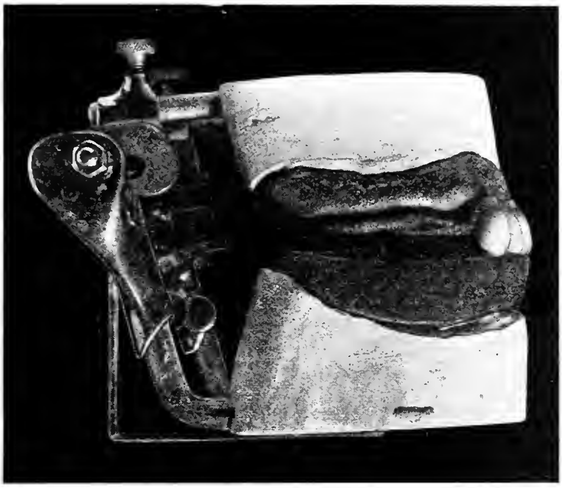
been so much abraded, or are so situated that they do not reach the margin of the lip, while in other instances their edges extend much below this line. In most edentulous cases it is advisable to establish the teeth in the first of these relationships. (Fig. 390.) With this end in view, the occlusal surface of the upper bite-plate has been trimmed to a distance one-sixteenth of an inch below the lower margin of the upper lip and represents, therefore, the position of the cutting edges of the anterior teeth. The general line of cutting edges is also parallel with the line of separation between the lips, a datum likewise furnished from the bite-plate.

In the setting up of the teeth, the upper plate should be removed and laid aside for reference. The correct distance between the jaws is preserved by means of a set screw on the articulator, or by measuring the distance between fixed points on the upper and lower casts with calipers before the upper bite-plate is removed. The calipers are laid aside and should be preserved for reference.

3. The Median Line.—The median line of the mouth having been marked on the casts, determines the position of the division between the upper central incisors which are the first teeth to be put in place. Their cutting edges should be in relation with the outer edge of the occlusal surface of the lower bite-plate. (Fig. 391.)

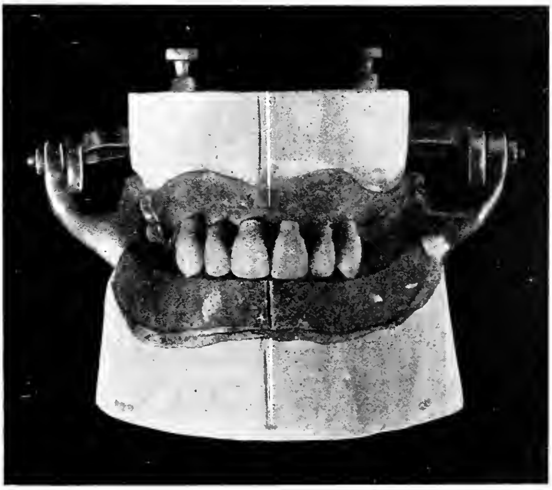
4. Inclination to the Ridge.—The inclination of the long axes of the teeth to the alveolar ridge has been largely determined by the lower portions of the labial surface of the bite-plate. These portions of the

Fig. 390



Six upper anterior teeth in position and in proper relation with lower bite-plate. Side view.

Fig. 391



Six upper anterior teeth in place, central incisors being on each side of the median line. Front view.

bite-plate were made to support the lips properly, and the anterior teeth must be so placed that their labial surfaces occupy the position of the labial surface of the bite-plate.

The teeth support and give form to the lip, but in addition, their inclination to the ridge affects their appearance. This must be some-

times made to accord with the demands imposed by the functional purposes of the denture. After the anterior teeth have been set up their inclination should accord with that observed for teeth of similiar shape in jaws similarly related.

The teeth of a normal or ideal denture in jaws having a correct antero-posterior relation are inclined about as follows: the long axes of all of the anterior teeth are inclined slightly outward from a vertical plane, the angle made with the vertical varying from a slight divergence to a considerable amount. The long axes of the central incisors slightly diverge from the sagittal plane of the body. Those of the laterals diverge slightly more, while those of the canines are more nearly vertically located. Where the lower jaw is distally related to the upper, the upper teeth often incline slightly backward, while where the lower jaw is protruding, the upper anterior teeth are usually inclined outward, the lower teeth having a lingual inclination from the pressure of the lips.

5. The Curve of the Arch.—The arch formed by the cutting edges of the anterior teeth should be in accord with that which is characteristic of the temperament of the patient. This is judged in part from the

Fig. 392

Curve of the anterior teeth in four dentures.

outline of the alveolar process when the bite-plate is made, and the curve on the occlusal surface of the bite-plate should be assumed by the teeth when they are set up. (Fig. 392.)

6. The Relative Position of the Teeth.—In the ideal or typical normal denture, the anterior teeth occupy definite relative positions.

Their cutting edges are arranged in the arc of a circle and they are placed regularly and symmetrically. This condition obtains, however, in nature in a comparatively small proportion of cases, an irregular alignment or a dissimilarity between the two sides of the arch being the rule rather than the exception. In the arrangement of the anterior artificial teeth, due cognizance should be taken of this state of affairs. In the effort to make an irregular alignment assume a natural appearance, the relationship which exists in natural dentures between the alignment of the teeth and their form, and the temperament of the individual should be recognized. In the tables prepared by Dr. A. H. Thompson, in Chapter V., will be seen what this relationship is in the basal temperamental types and in the binary compounds, and this general principle should be followed in the determination of the relative positions of the teeth for a given case. It would be manifestly out of place to arrange the teeth irregularly for a patient of a temperament in which the arrangement is commonly regular. Furthermore, any irregularity imitated should be that which observation has shown to be associated with the teeth and temperament of such cases. It should also be borne in mind that age has an influence in the production of irregularities of the anterior teeth through causes which operate subsequent to the original positioning of the teeth. Attention should be given to the association between the irregularities imitated and the antero-posterior relation of the jaws, and in all instances the general relation between cause and effect should be borne in mind, and results established to accord with probable operating causes.

The regular alignment of the natural teeth has been described. This is to be established with artificial teeth in mouths of patients of a temperament of which this is characteristic, as, for instance, in those of the lymphatic temperament. It should be reproduced also for younger patients and those in whose mouths regularity of the teeth would be in accord with regular and symmetrical features of the face. On the other hand, irregularities of the teeth are to be imitated in the mouths of young patients of the nervous temperament, since the natural teeth in these mouths are frequently irregularly aligned.

The irregularities of the anterior teeth commonly observed are those with the long axis of the tooth departing from its position in the ideal form of the denture, and irregular positions of the occlusal edges of the teeth.

The following may be advantageously imitated in appropriate cases: (Fig. 393.)

1. Rotation of the centrals with their distal surfaces labially placed.
2. Rotation of centrals with their distal surfaces lingually placed.
3. One central overlapping the other with laterals overlapping.
4. Elongate centrals.
5. Overlapping laterals.
6. Alteration in position of the long axes of the teeth.
7. Centrals slightly lingually inclined.

The lower teeth are irregularly placed frequently as follows:
1. Centrals with the distal surfaces turned outward.
2. Rotation of the lateral incisors.
3. Overlapping of laterals or centrals.
4. Overlapping of one or both canines.

Fig. 393

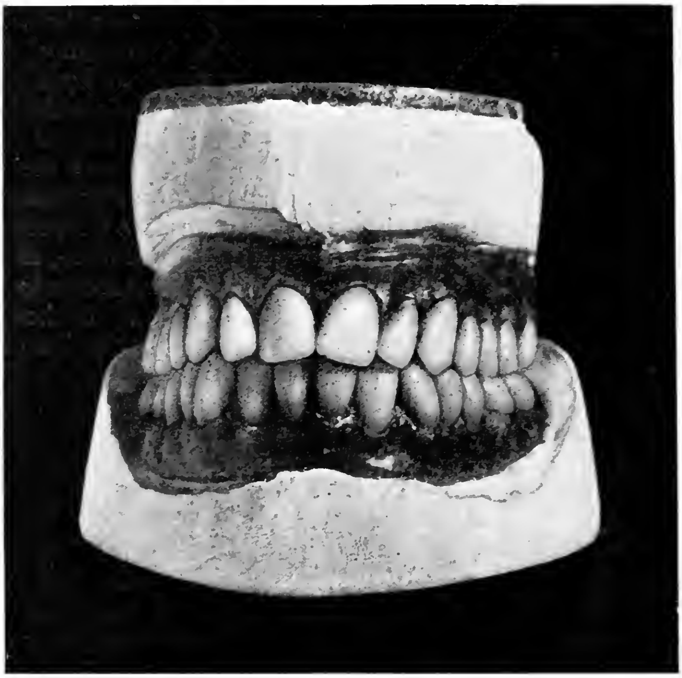


Fig. 394

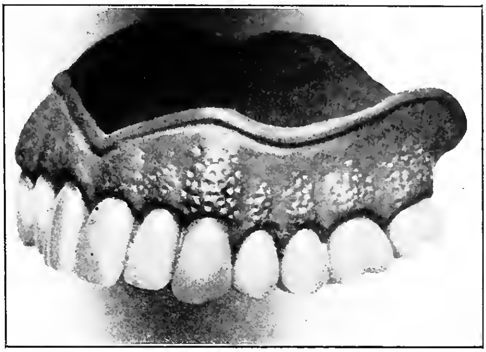
Dentures showing irregular position of the anterior teeth.

Spaces do not exist between the teeth of a natural denture without some abnormal operating cause. Their existence is usually a defect in the beauty of the denture, and the imitation of this in artificial teeth is seldom justifiable, unless it be in imitation of a condition known to have existed in the mouth of the patient.

7. The State of Wear of the Teeth.—One of the defects commonly observed in artificial dentures is that the teeth are inserted without an

alteration of their occlusal surfaces to imitate that produced by the wearing of the teeth from use. In Chapter V., the question of the wearing of the teeth was considered at some length. Artificial teeth should be made to accord with the probable state of wear of the teeth of the patient. The wear on the teeth in a natural denture is determined partly by the temperament, the form of the teeth, and the manner of movement of the mandible peculiar to the individual. While not directly related to the age, it must be, in some measure, in accord with it, or the length of service which the denture has seen.

Fig. 395, A



Denture showing imitation of first degree of wear.

It is seldom advisable to imitate greater degrees of wear than the second, as further wearing is of seldom occurrence under the conditions of modern civilization and is infrequently observed in the natural teeth.

It is seldom the case that an artificial denture is required in a patient so young that, had the natural teeth remained, no evidences of wear would have existed. In any but the youngest patients the cutting edges of the incisors should be ground with a corundum wheel to portray this evidence of their use, and the amount of wear should be graduated from a slight alteration of the cutting edges to that observed in the second degree of wear in which the dentine is exposed. What may be considered typical cases are illustrated in Fig. 395, and in the imitation of this condition the relation of cause and effect, as above alluded to, must be constantly borne in mind. To illustrate in detail one case which may be taken as a fair sample, Fig. 395, A, presents the conditions which might reasonably exist in a natural denture of a patient about thirty-five years of age. The forward movement of the lower jaw has caused the wearing of the upper incisors into slight depressions where they were in contact with the lower teeth. The lower teeth have

Fig. 395, B

Denture showing imitation of second degree of wear.

similarly worn. Fig. 395, B, shows a case in which there has been considerable over bite of the incisors, where the upper teeth have been worn at the expense of the lingual plate of the enamel, the lower teeth at the expense of the labial. Fig. 396 shows a case of the second degree of wear which might be found in the mouth of a patient aged fifty years, where the cusps have worn down sufficiently to permit the mandible to move forward, producing an edge-to-edge bite, with the complete obliteration of the occlusal ends of the teeth, the exposure of the dentine, and a slight chipping of the enamel. Other typical cases of wear in natural dentures may be observed by the dentist and imitated in a similar manner.

It is suggested by Dr. A. DeWitt Gritman that the grinding of the incisors and the canines in the first degree of wear be deferred until the denture is completed and tried in the mouth of the patient.

8. **Recession of the Gums.**—This condition, when of a physiologic nature, is seldom observed in the mouths of patients younger than thirty-

Fig. 396

Denture showing imitation of recession of the gums.

five years of age, although it is progressive by almost imperceptible degrees up to this time. It is seen most frequently in patients of the sanguine and bilio-sanguine temperaments. Pathological recession of the gums, attended with an exposure of the cementum and a thickening of the gingival margin, with a disappearance of the gum occupying the interproximal space, is frequently seen in these patients at a later period in life and may be imitated to advantage in such cases. (Fig. 396.)

9. **Individual Peculiarities.**—Defects in the teeth of a denture, which have assumed the form of an individual peculiarity, are often to be reproduced in the mouths of patients in which they are known to have existed. The defects are those of form or structure. In the mouths of patients of the nervous temperament with delicately shaped teeth, filling operations have usually been necessary before the time at which a plate denture is required, and in such cases, the insertion of fillings

in the anterior teeth is a measure which frequently adds to the natural appearance of the denture.

Where a prominent gold filling has existed in a natural tooth, it may be reproduced in the artificial, and will tend to preserve the identity of the individual, in which cases it is the indication.

The lateral incisors are usually the first oral teeth requiring filling operations, and in those cases in which fillings are inserted for purposes of naturalness, and without a history of their former existence, these teeth should be selected to receive them. In the insertion of the filling regard should be paid to its placement in a position in which carious cavities commonly occur. A gold filling on the mesial surface of either or both laterals or upon the mesial or distal surfaces of either central will answer these several requirements, and in all cases the relation of cause and effect, the latter represented by the filling, should be borne in mind.

Discoloration of the teeth is another condition to be imitated to advantage in selected cases. One condition to be imitated is the staining of the cervical third of the labial surface of the crowns, a yellow discoloration being sometimes found in these portions of the natural teeth. The imitation of an eroded area in this location by grinding the surface which is then stained yellow, and the staining of the occlusal surfaces of the teeth to imitate the discoloration of the dentine observed in the mouth of users of tobacco, are the ones most commonly of service.

The imitation of the discoloration incident to devitalization of a tooth may be some times justifiable, but rarely except in those cases in which a similar condition was known to exist.

The opaque white spots on the surface of the incisors, indicative of an error in the development of the enamel, is also a condition which may be reproduced. The indication for this, however, seldom presents itself, and it is only really necessary for partial dentures in which an artificial tooth is to be made to match natural teeth exhibiting this condition.

The method of producing these stained effects is that recommended by Dr. George H. Wilson and described in a paper "Artistic Staining of Artificial Teeth," in the *Ohio Dental Journal.*

TINTING AND STAINING PORCELAIN TEETH.

Changes may be made in the color or shades of teeth, or devitalized and discolored teeth may be imitated, by the system demonstrated by Dr. George Cunningham at the Columbian Dental Congress, which consisted in the application of a set of paste colors or the stains prepared and furnished by Poulson of Dresden or Ash Sons of London.[1]

The colors usually employed in china painting will answer very well for the purpose, and a small selection, consisting of sepia, ivory black,

[1] From paper on "Artistic Staining of Artificial Teeth," in *Ohio Dental Journal*, by Dr. George H. Wilson.

rose pompadour (gum color), ivory yellow, brown yellow, celestial blue, and relief white will be sufficient with which to form almost any shade required in the imitations of the usual discolorations of the teeth as met with in the natural organs.

The implements required for the mixing and application of the tints are a plain glass slab, on which to mix the colors in small quantities; a small palette knife; a small, short-bristled brush for stippling or spreading the color, such as can readily be formed by cutting off the bristles of a camel's hair or sable brush, so that the remainder is short, stubby, and square at its end; alcohol, with which to clean the teeth; brushes; oil of cloves, oil of lavender, or turpentine to thin the paints to proper consistence.

The grays, yellows, and browns are the tints most frequently required in imitating the discolorations of the natural teeth. Ivory black is of course not to be used by itself, but it is indispensable as a means of deepening the color of the grays and browns.

In the use and application of pigments for the purpose of staining porcelain teeth the operator should study the colors of the natural organs as met within the mouths of patients, and he should acquire experience in noting the effect of admixture of the pigments when applied to porcelain teeth. This is essential, as the colors when developed by exposure to high temperatures are not always of the degree and shade expected. A few experiments, which can easily be made upon odd teeth by means of the Downie or Custer furnace, will enable the operator to apply the colors with some degree of certainty.

Imitations of gold fillings in porcelain teeth are admissible only when done for the purpose of closely imitating conspicuous natural teeth, thus protecting the patient from sudden change of appearance. The tooth or teeth to be so treated are to be first fitted accurately to place and carefully articulated. The portion of the tooth to receive the imitation filling should be slightly depressed by grinding with a corundum wheel, so as to allow for the required thickness of the gold, which is the same as is usually employed by china decorators. It is known as "Roman gold," and is laid on with a camel's hair pencil. Usually three or four layers will be necessary to enable the gold to withstand the attrition to which it will be subjected in the mouth. Each layer must be separately burned in the furnace.

The occasions requiring tinting or staining are not numerous, and the system should be applied with taste and judgment. These occasions are found in cases where it is necessary to imitate the discoloration of a devitalized tooth; to deepen the color of the cuspids; to imitate the discoloration of the dentine left bare by the recession of the gums; to darken the dentine between the plates of enamel on the cutting edges of the teeth of elderly subjects; to imitate the opaque or white spots in the enamel of incisors or cuspids, or the yellow spots occasionally seen on the surfaces of the incisors.

In applying the stains the tooth should be thoroughly cleaned with alcohol, dried, and held by the pins with a pair of pliers: the color is

mixed with oil of cloves or lavender and applied with a camel's hair pencil, the quantity or thickness being governed by the depth of shade required.

The color is fixed by subjecting the teeth to a temperature of about 2000° F. The firing may be satisfactorily accomplished in either of the furnaces above named, or, as described by Dr. George H. Wilson, "by shaping a piece of No. 36 platinum plate so as to cover and enclose the teeth, except on one side, which is left open as a peep-hole. This miniature oven or furnace containing the teeth is placed over the Bunsen burner for about five minutes, when the flame from the blowpipe is placed against the outside of the clay slab, upon which it is held, and gradually bringing it over upon the top of the platinum," two minutes' work of the blowpipe being sufficient, to vitrefy and fix the colors.

"Atrophy and worn conditions are imitated by grinding and then staining." Gum colors are formed by the use of the rose pompadour, the depth of the shade being secured by varying the amount of the relief white.

THE ARTICULATION OF THE BISCUPID AND MOLAR TEETH.

When all is said about the purposes of artificial dentures, it will be seen that their chief function is the repair of the apparatus by which mastication is accomplished. The molar and bicuspid teeth are paramount factors in the accomplishment of this object. Their form and arrangement should be determined almost solely by considerations relative to this purpose. They also contribute by their arrangement to the general object of plate maintenance. The correct placing and form to be given them to promote these purposes will now be considered.

A knowledge of the form and functional relations of the natural teeth will be of great assistance in the articulation of the artificial bicuspids and molars. While it is not possible to exactly reproduce in the artificial teeth the form and arrangement of the natural, because of essential differences in the conditions attending their use, much may be learned from a study of the normal operation of mastication in a typical or ideal natural denture. As placed in the mouth, the natural teeth are firmly imbedded in the alveolar process, and during their use for purposes of mastication, stress may be applied to them in a variety of directions. On the other hand, artificial teeth are mounted upon a base supported upon the mucous membrane, and they must be so formed and located that not only is the stress which is exerted upon them in the crushing of the food to be so arranged as to be best resisted by the tissues supporting the plate, but that stress must be so disposed as to hold the dentures firmly upon their base instead of causing them to be displaced. These essential differences, therefore, exist between natural and artificial dentures and the principles utilized in the former must be modified and adapted to promote the best interests of the latter.

Two objects are, therefore, held in view in the articulation of artificial

teeth: first, to have the teeth shaped and located so that they may be brought into effective functional relations during the movement of the mandible; second, to so arrange them that the stress brought upon them during their use in mastication will serve to maintain the dentures upon their support and not to displace them. How may this be accomplished?

Let us first direct attention to several characteristics of an ideal natural denture which have to do with the function of mastication. In the natural jaw there is a definite relation between the form of the occlusal surfaces of the teeth and the path which the condyle pursues, and in consequence, with the movement of which the mandible is capable. It has been shown in Chapter IV. how this relationship renders the denture a more effective masticating apparatus. This principle is to be applied to artificial teeth; for while it is rarely the case that in a natural denture the teeth absolutely follow the typical design for the apparatus,

Fig. 397

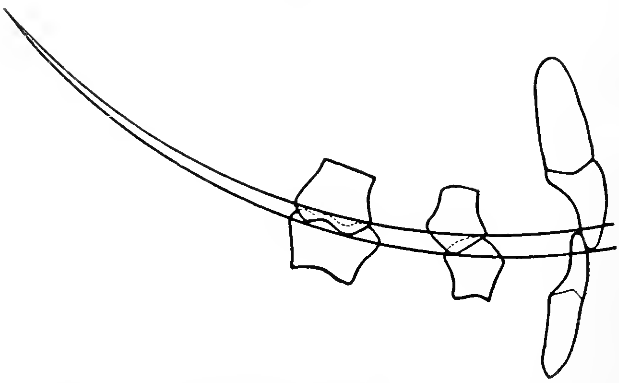


Diagram showing typical proportion between cusp length overbite and compensating curve. Modified from Bonwill.

in the artificial denture the forms and positions of the teeth are under control and may be determined and co-ordinated with the mandibular movements.

In the natural teeth the molar and bicuspid series presents two rows of cusps, the outer and inner. The buccal cusps of the lower and the lingual of the upper are received into fossæ between the cusps of the opposed series. While it is not possible to exactly reproduce in the artificial teeth the forms of the individual cusps constituting these two lines or the fossæ into which they are received, it is possible to represent the lines of cusps by ridges which are received into sulci, and for all practical purposes the masticatory function may be executed by teeth thus shaped.

It will be remembered that in the typical natural denture the so-called "compensating curve" of the bicuspid and molar teeth is directly correlated with the path pursued by the condyle in its forward excursion.

(Fig. 397.) This provides for a sliding contact between the two series, upper and lower, in the forward movements of the mandible until its anterior end is depressed by the sliding of the lower incisors upon the lingual surface of the upper. The compensating curve is a continuation of, or is concentric with, the path pursued by the condyle. This correlation is to be established by the form and arrangement of the artificial teeth to subserve a similar end.

It will also be remembered that the buccal cusps of both upper and lower series are placed at a progressively higher level from the first bicuspid to the last molar. Also that the buccal cusps of the lower and the lingual cusps of the upper are the larger of the lines of cusps and that these become relatively larger from before backward. This permits a sliding contact between the teeth in the lateral excursion of the jaw. When the mandible is moved to the right side for instance, the high buccal cusps of the lower series on the right side slide upon and come in contact with the short buccal cusps of the upper, the large lingual cusps of the upper being at this time in contact with the lingual cusps of the lower series. (Fig. 398.) On the side opposite to that from which the movement has taken place, the high buccal cusps of the lower have moved upon the large lingual cusps of the upper, the descent of the condyle on this side making it necessary that two long cusps be in relation to preserve the contact. When the mandible is brought back to the position of the resting bite, the sliding contact is maintained. A correspondingly similar relation of the teeth exists when it is carried to the left side. This characteristic of the ideal natural denture is also to be reproduced in the artificial.

In the natural denture, when the mandible is protruded in incision to bring the occlusal edges of the incisors into contact, there is no conjact between the distal teeth of the two series. In the artificial denture the overbite of the upper incisors is to be made less than its natural pro-

Fig. 398

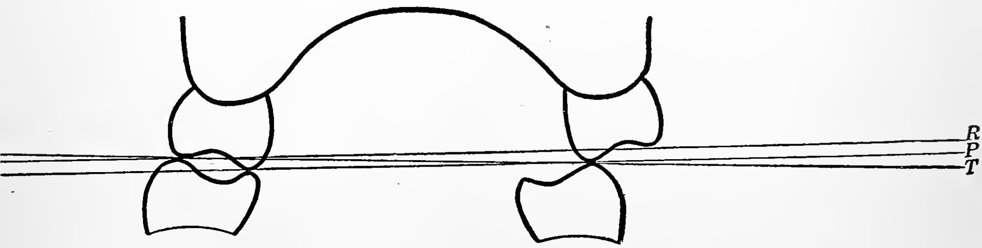
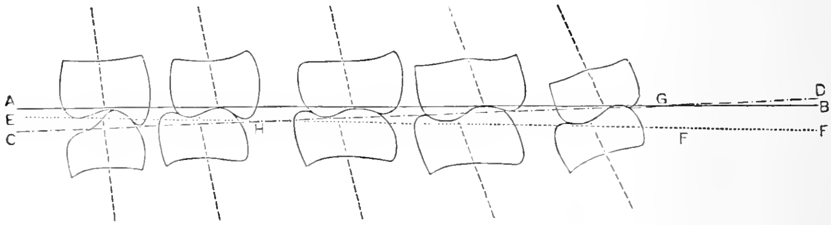


Diagram illustrating contact of cusps in lateral excursion of the mandible. Section through jaws at position of second molar. O P, line touching lingual cusps of upper molars; L R, line touching buccal cusps of upper molars; S T, line touching buccal cusps of lower molars, showing the downward movement of the mandible on the right side necessary for contact of the cusps.

totype, so that when the mandible is protruded for incision and the incisors are in edge-to-edge relation, contact between the last molars of the series is to exist at the same time. It will be seen that this ar-

rangement of the forms and positions of the artificial teeth provides for a simultaneous contact between the series of the two sides during the lateral movement of the mandible in mastication. This serves to maintain both upper and lower plate dentures in place by pressing them firmly upon the tissues which give them support. During the use of artificial dentures for mastication this provision greatly contributes to their maintenance. It does not, of course, provide against displacing stresses occurring in mastication before the two series have come into contact, and during the passage of the cusps through the food until those of the two series touch; but in the retraction of the jaw from this point to the position of the resting bite, during which time the chief crushing of the food takes place, the teeth preserve a sliding contact which tends

Fig. 399



Diagrammatic view of the relative height of the buccal and lingual cusps of the molar and bicuspid teeth. (Walker.)

to keep the dentures in place. This arrangement of the teeth also assists in the maintenance of the plates during the operation of incision, for as soon as the incisors have met through the food that is being incised, the distal teeth are in contact, and as the mandible is retracted to the position of occlusion, the lower incisors slide upon the upper and the plates are firmly pressed into place.

We shall now discuss considerations pertaining to the proper placing and correct form of the teeth to accomplish these ends. The bicuspids and molars obtained from the manufacturers are illy shaped, as a rule, to serve the ends of this arrangement. The upper molars and bicuspids, for example, have longer buccal than lingual cusps which is the reverse of that observed in the natural teeth. They are also, as a rule, too narrow bucco-lingually. Teeth should be selected, therefore, which will admit of considerable alteration in their form. It is especially important to have a sufficient bulk of porcelain occluso-gingivally, so that the grinding of a sulcus between the buccal and lingual cusps will not too greatly weaken them. They should also be as wide bucco-lingually as possible. The alteration in form, as recommended by Dr. Bonwill, may be best done with corundum stone one and one-half inches in diameter and an eighth of an inch wide, with a round edge. It is purposed to grind them so that the buccal and lingual cusps shall have the corresponding relative size and height characteristic of the natural teeth.

This is done chiefly by deepening the sulcus between the buccal and lingual cusps and altering the height of these cusps. Fig. 399 gives a diagrammatic profile view of the upper and lower series of one side. It will be observed that the buccal cusps of the upper are smaller and are placed at a progressively higher level from before backward. This latter characteristic is obtained by an actual decrease in the height of the cusps and by an increasing inclination of the long axes of the teeth from the vertical. In the lower series the buccal cusp increases in size and is placed at a progressively higher level, as illustrated in the figure. For the upper artificial teeth, therefore, a sulcus should be ground which approximates nearer to the buccal side of the teeth as one goes from the first bicuspid to the second molar. The buccal cusps must be shortened and their size diminished. The lingual cusp is to be rounded and preserved as high as possible.

It is suggested by Walker[1] that the second molar be given more nearly the form of the third natural molar by having a pronounced lingual cusp and a very small buccal cusp. It is observed in the natural denture that the lingual cusp of the third molar is chiefly the one in contact with the lower teeth in the movement of the mandible. In the artificial teeth this arrangement will promote the stability of the denture by removing the lingual cusp from occlusal contact, and it will be seen that as this cusp is farthest removed from the line of the alveolar ridge, placing it out of contact with the lower will reduce the displacing tendencies acting upon the plate.

In cutting the lower teeth the lingual cusp is to be reduced in height, and the sulcus dividing the two lines is to approach the lingual surface of the series more closely from before backward. Bonwill has called attention to the advisability of removing the lingual cusp from the first lower bicuspid, because it does not have functional relations with the upper series in the movement of the jaw. The buccal cusps of the lower are to be rounded and preserved as high as possible. (Fig. 400.)

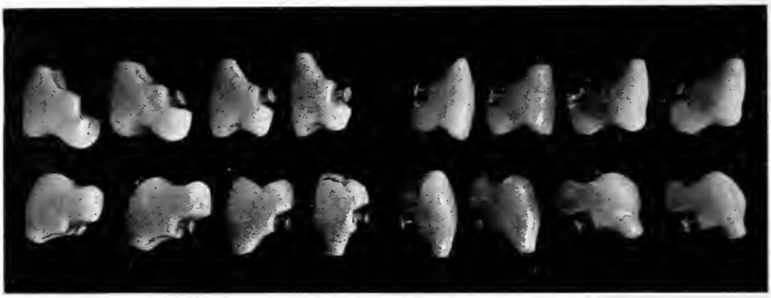
Recently, several manufacturers have placed so-called "anatomical molds" upon the market which are a great improvement upon the teeth formerly in general use. These new molds are designed to give the occlusal surfaces of the teeth such cusps and fossæ as to enable one to set them up in correct occlusion with the same interdigitation of the cusps as obtains in natural dentures. Many of these molds give excellent occlusal relations of the cusps and in some instances they may be made to articulate in the side and forward movements of the articulator in a very satisfactory manner, although some slight alteration of a cusp here or there is usually necessary with even the forms of best design. It is hoped and believed that before many years forms will be obtainable which will require little or no alteration for use in the average case.

[1] The Dental Cosmos, vol. xxxviii., p. 41.

THE TECHNIQUE OF THE SETTING OF THE BICUSPID AND MOLAR TEETH.

The six upper anterior teeth having been correctly placed, as already described, the placing of the molar and bicuspid teeth upon the casts is then undertaken. Bearing in mind the relationship between the cusp length, the overbite, the compensating curve, and the path of the condyle, it will be seen that these must be in accord in each individual denture. If the casts, therefore, have been correctly placed upon an articulator capable of individualizing the movements of the mandible, and

Fig. 400



Series of artificial bicuspid and molar teeth cut for articulation.

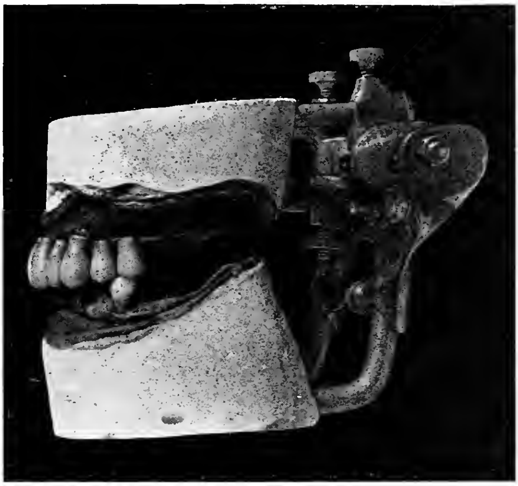
the paths of the condyles have been recorded, and the articulator adjusted to reproduce them, then the teeth must be arranged so that the cusp length, overbite and compensating curve factors are in accord therewith. As the overbite may be arranged to accord with the cusp length and the compensating curve after they have been established, these two factors must be harmonized with the condylar path. It will be remembered that long cusps are associated with a marked downward inclination of the path of the condyle, and that short cusps are found in cases in which the path is not much inclined. It will also be remembered that long cusps are associated with a compensating curve of short radius, and short cusps with a curve of long radius. If, therefore, the length of the cusps is decided upon for a particular case to accord with the path of the condyle, only one of the fixed factors in this joint relationship, the compensating curve, remains to be determined, and this curve may be made to accord with the cusp length and the condylar path.

The lengths of the cusps of the individual teeth have a direct proportion to each other, so that the cusps of one tooth of the series having been determined, the others may be made to accord therewith. These facts make it evident that if in the process of setting the teeth, the length of the cusps of the bicuspids is determined, then the other related factors may be made harmonious therewith.

The length of the cusps on each side is to be determined in part by the temperamental indication of the patient, but chiefly by reference

to the path of the condyle in accordance with the principles above outlined. These teeth should be cut, therefore, and placed in their proper position upon the upper cast in relation with the lower bite-plate. It will be remembered that the compensating curve begins at this point, and they should be placed tentatively in line with the upper teeth already in position and in correct relation with them, carefully preserving the distance between the casts by means of the calipers already referred to. The lower bite-plate is removed, and the second lower bicuspid cut to accord with the height of the cusps of the upper teeth, is then placed to correctly articulate with them. (Fig. 401.) The buccal

Fig. 401



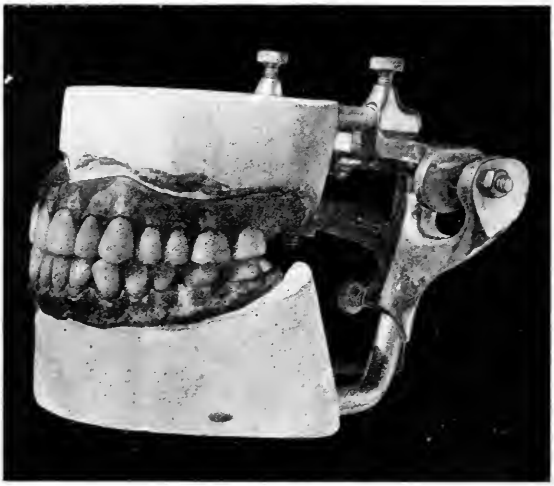
Casts on articulator with ten upper anterior teeth and second lower bicuspids in place.

and lingual cusps of the first upper bicuspid should be in the same horizontal plane, and the teeth given correct positons so far as the direction of their long axes is concerned. This, it will be seen fixes the path of movement of the lower bow of the articulator, representing the lower jaw, while the teeth are in contact. The lower cast may be moved in relation to the upper only along fixed paths so long as the sliding contact is preserved, and the teeth, which are subsequently placed in position, may be made to come into contact in correct functional positions.

The first molar teeth of the lower jaw are then to be placed in position. They are cut with cusps of size relative to the lower bicuspids already in place, and are to have their distal cusps elevated in accord with the prospective compensating curve. Their buccal cusps should also be slightly higher than their lingual. The lower bow of the articulator should now be moved to one side, and it should be observed if the contact between the bicuspids is interrupted because of contact with the molar, or whether the contact of its cusps with the second upper bicuspid accords with that of the other teeth. If it does not, it

should be so altered in cusp length or position or inclination as to make it in contact with the second upper bicuspid during these movements. The first upper molar on each side is then to be placed in position in proper occlusal relation with the first lower. The lower bow of the articulator is again to be moved laterally; the sliding contact of the upper molar is to be tested in a manner similiar to that of the lower, and any alteration in its position or cusp length made to insure its continued contact during these movements.

Fig. 402

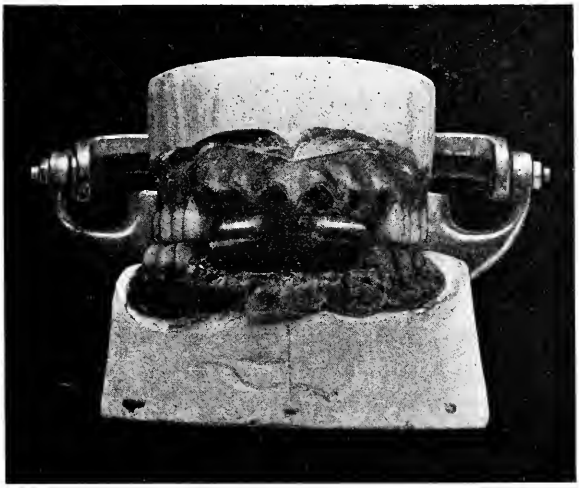


Casts with all bicuspids and molars in place. Side view.

Enough of the teeth have been placed in position now to take cognizance of the compensating curve, and the lower bow of the articulator should be carried forward to test this. In this movement the lingual cusps of the upper should slide in the sulci of the lower and slightly upon the buccal cusps of the lower. The more divergent are the lines of the teeth from the canines backward, the more will the upper lingual cusps mount the lower buccal, and the more nearly parallel are these lines of teeth, the more will these cusps slide in the grooves. If the compensating curve is not sufficiently great, the contact of the molars will be interrupted by this movement. It is evident, therefore, that the cusps of the upper and lower molars are placed below the proper compensating curve and the curve must be increased by inclining the long axes of the molar teeth a little farther forward, and then raising them to the necessary position of the compensating curve. On the other hand, if in this movement it is the bicuspids which are separated, it is evident that the compensating curve is made too great, and the line of contact between the upper and lower molars is above their desired position in the proper compensating curve. Any necessary alterations in their positions to make them accord with this arrangement must then be made.

The second lower molars are then to be placed in position, having been cut to tentative form. The lateral movements of the articulator are produced as before, and the contact of their cusps with those of the first upper molar tested in a similiar way. Alterations in their form or position will be indicated to make them accord with the preservation of an uninterrupted contact with the upper teeth in these movements. It is particularly important to remember their natural lingual inclination and the increased height of their buccal cusps. In the forward movement of the lower bow of the articulator their conformation to the de-

Fig. 403



Lower bow of articulator carried to one side to show contact of molars.

sired compensating curve is tested, and they should be located in accordance with the indications.

The second upper molar is then to be placed in position and its form altered or its position changed as the movements of the lower bow of the articulator indicates to be necessary. (Fig. 402.)

In the making of these adjustments between the teeth, it is first desirable to bear in mind their general relation to the compensating curve. It is also desirable to place the molar teeth as nearly over the alveolar ridges as possible, and, except in cases of extreme absorption of the process, this may be measurably accomplished.

Inasmuch as the line of force upon the two dentures should as nearly as possible coincide with an imaginary line drawn from one ridge to the other, the long axes of the artificial teeth should be as far as is expedient placed in this imaginary line. (Fig. 404.) The outward inclination of the upper teeth and the lingual inclination of the lower will make this possible, and not conflict with the other requirements in the position of these teeth. In general, it may also be said that the line

of the occlusal surfaces of these teeth should be about midway between the upper and lower alveolar ridges, although differences in resorption in the two jaws or in the two sides of the same jaw may make slight alteration in this.

The first lower bicuspid is now to be placed in position in correct functional relations with the upper canine and first bicuspid. The lower bow of the articulator should be moved both laterally and forward to test the contact of this tooth in these various relations.

Only the six lower anterior teeth now remain to be placed in position. It is desirable that they should fulfil both functional requirements and

Fig. 404

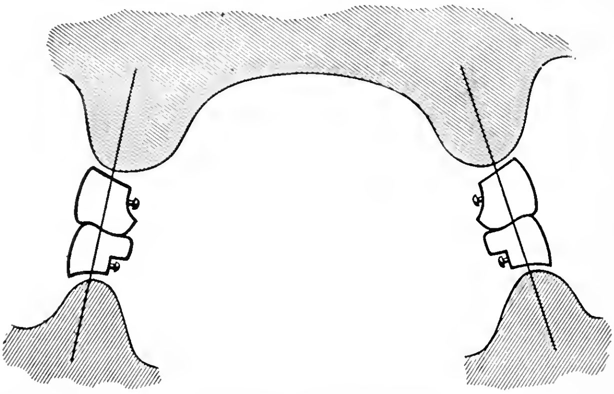


Diagram showing section through mouth with molars in occlusion and line drawn between edges corresponding to the long axes of the teeth.

those imposed by considerations of appearance. Their position relative to each other to fulfil the demands of appearance have already been considered. To subserve the ends of function, they are to be placed in position so that when the lower bow of the articulator is protruded, they are in occlusal contact with the upper teeth. Where conditions of wear are to be simulated, they must first be ground for this purpose and then placed in such position that when the lower bow of the articulator is moved forward, their occlusal ends touch those of the upper teeth. They must also be arranged so that in the lateral movement of the jaw they do not strike the upper teeth and thus displace the dentures.

In summing up the characteristics of artificial teeth arranged according to this plan, it will be seen that they differ from the natural teeth in the following particulars: the cusps are lower than their natural prototypes, and this is because by this means the stable retention of the plate is best promoted. The higher the cusps are, the greater leverage there is upon the dentures. It may be asked why the sliding contact between the dentures might not be preserved and the maintenance of the plate best secured by having the teeth with flat surfaces instead of with cusps. Of this it may be said that the advantage of the cusp

and fossa principle in the mastication of food has already been outlined in Chapter IV. Furthermore, clinical experience has shown that artificial dentures mounted with teeth whose cusps have been ground are by no means as effective for their wearers in the preparation of food, as those in which the cusps exist. G. V. Black has also shown the greater efficiency of a cusped crusher in the preparation of various articles of food. His experiments with the phago-dynamometer show that whereas the average force which may be exerted with the natural bicuspid and molar teeth is over 150 to 175 pounds, the average possible with artificial dentures is only from 20 to 30 pounds. He has also shown that this latter is not sufficient in many instances to crush some of the more resistent articles of food, while Head has demonstrated the greater masticating efficiency of the triturating motion which, of course, is best obtained in artifical dentures articulated according to the plan above outlined.

Because of the flattening of the floor of the glenoid fossa in edentulous cases, as mentioned in Chapter IV., it will be seen that the path of the condyle is not so inclined as that existing earlier in life, when the natural teeth are in position. In consequence, the compensating curve for artifical teeth will be of longer radius than that commonly formed by natural dentures. It has also been shown that for purposes of stability of the plate, the natural overbite is to be lessened.

Because of the resorption of the alveolar ridge, the teeth of any artificial set must be slightly smaller than the natural teeth which preceded them. This fact, together with the necessity already mentioned for placing them as nearly as possible over the ridge, will make the position of their long axes slightly different from that of the natural teeth.

To Dr. E. S. Ulsaver is due the credit of working out the following method, quoted by Clapp,[1] of determining the tooth curves in the biteplates after which the upper teeth may be set up upon the lower biteplate, and the lower in turn articulated with the upper:

"Upon the occlusal surface of the lower trial plate, which was made flat and has not been changed, is dusted a white powder, such as soapstone or talcum, with sufficient evenness so that any scratches upon that surface will show. The trial plates are then closed together and gentle pressure is made from the most anterior portion of the upper model to the most anterior portion of the lower model by means of the thumb and finger. By pressure on the anterior end of either condyle slot the upper model is moved laterally back and forth several times. When the trial plates are separated it will be seen that the occlusal margin of the upper trial plate, on one side, has rubbed the powder noticeably in several spots. If both occlusal surfaces are smooth and level, this rubbing will probably occur first in the bicuspid region.

"The wax of the lower trial plate is now scraped where the powder was rubbed. For this some workers prefer an old blade from a safety razor, and some prefer a wooden handled ink eraser, such as is common in business offices. When the wax in the rubbed area has been hol-

[1] "The Mechanical Side of Anatomical Articulation," by George W. Clapp, p. 72.

lowed somewhat, fresh powder should be dusted on and the rubbing and scraping process repeated. When the necessary technic has been acquired, the scraping or carving can be done rapidly, since the indications of the first rubbing will prove a reasonably accurate guide for extensive carving. But it cannot be urged too strongly upon dentists who care to anatomically articulate dentures, that in the first two or three sets of trial plates there should be given to this carving enough time and attention to demonstrate the principles and methods involved. The time spent in doing this will bring ample rewards in the future. Trial-plate making will never again offer difficulties.

"This form of carving should be continued on one side only until the upper trial plate rubs the powdered surface of the lower to the outer margin on that side. The other side may then be carved in like manner. This is as far as this form of carving should be carried, since it is not desired to lower the labial margin of the lower trial plate. If the trial plates be now closed together and examined from the lingual, it will be seen that while the outer margin of the lower trial plate remains undisturbed, the occlusal surface has been considerably inclined toward the lingual. This inclination will be least in the molar region and greatest at the median line.

"If the upper model be moved to the right the trial plates will now remain in contact on the left side, but separate noticeably in the molar region on the right. The amount of separation will depend almost wholly on the inclination of the condyle slots. If this inclination be very slight, say only 10 degrees, separation between the heels will be slight. If, however, the inclination of the condyle slots be 33 degrees, which Gysi thinks is the average, the separation will be noticeable. If the inclination of the condyle slots should be 60 or 70 degrees, as is found in some cases, the separation will be very marked.

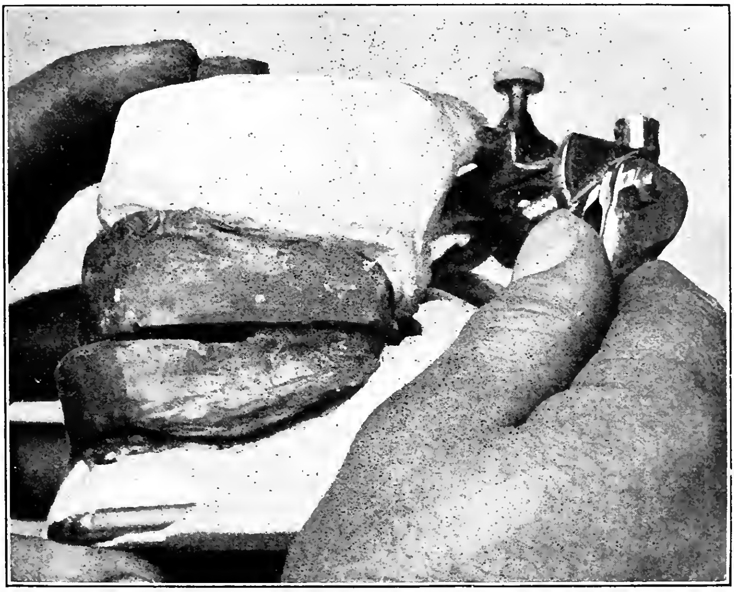
"The next task is to so continue the curves in the occlusal surfaces of both trial plates that this separation in the lateral movement may be overcome. This may be done by building up the heel of the lower trial plate into the compensating curve and then carving the heel of the upper trial plate to fit the lower as thus built.

"The heel of the lower trial plate is built up as follows: Cut across one end of a sheet of base plate wax as it comes in the box, making a strip of about three-fourths of an inch wide. Soften this on one side and fold, and repeat the softening and folding until a roll has been made which is soft all the way through. With gentle heat, soften one heel of the lower trial plate, place the little roll thus made on the heel, and attach it firmly by means of a hot spatula thrust through the roll and into the wax. When the union is sufficiently firm for working purposes, moisten with water the occlusal surface of the upper trial plate directly over the roll. Before bringing the trial plate together, move the upper model about one-eighth of an inch toward the side on which the roll is attached. With the upper thus moved laterally, press the models together until the trial plates come in contact on the one side opposite to the roll. (Fig. 405.) Separate the trial plates and trim

away the excess of wax to the lingual and buccal. It will be observed that the upper ridge did not flatten the roll horizontally, but that this surface shows an inclination upward and backward from the occlusal surface of the lower trial plate. This is the beginning of the compensating curve. This surface also slopes lingually; that is, the elevation is less at the lingual margin than at the buccal margin. This is the beginning of the lateral curve in this section.

"It has been suggested that the upper model be moved laterally only about one-eighth of an inch, because it is found that if the model be pulled farther, the compensating and lateral curves are exaggerated. So far as we are able to determine at present, practically all the benefits

Fig. 405



Upper models moved laterally and pressed down on roll on heel of lower bite. (Clapp.)

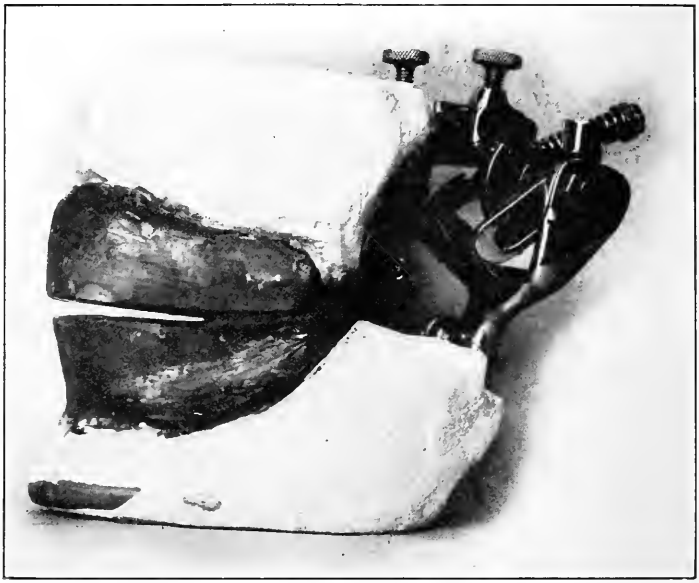
that would be possible from even the most exaggerated curve are secured by the curve that results from moving the upper model one-eighth of an inch. Dentists who wish to carry their education out in this matter will find it profitable to make a set of trial plates and in carving move the upper model as far laterally as the articulator permits. This will give an understanding of the compensating and lateral curves which will be impossible of attainment by any other means.

"When the upper model is allowed to return to a position of central occlusion, the trial plates will be kept apart by the built-up heel of the lower. (Fig. 406.) At the point of contact with the lower, the upper must be carved to permit the trial plates to come together all around. Begin scraping at the buccal-occlusal margin in the cuspid region, scraping harder as the heel is approached. The scraped surface of the

upper should have just the same upward and backward inclination as the built-up heel of the lower. It should have just the same lateral curve, so that in the position of central occlusion the built-up surface of the lower and the scraped surface of the upper show nearly exact contact.

"The heel of the upper should be scraped in a curve somewhat longer than that shown by the built-up wax on the lower trial plate. That probably extended forward only to the bicuspids. It terminated abruptly, leaving a sort of 'jumping-off place.' The curve of the upper necessary to fit the built-up lower may be carried forward to the location of the cuspid. When the trial plates are in contact all around, this will leave a triangular open space anterior to the flattened roll.

Fig. 406



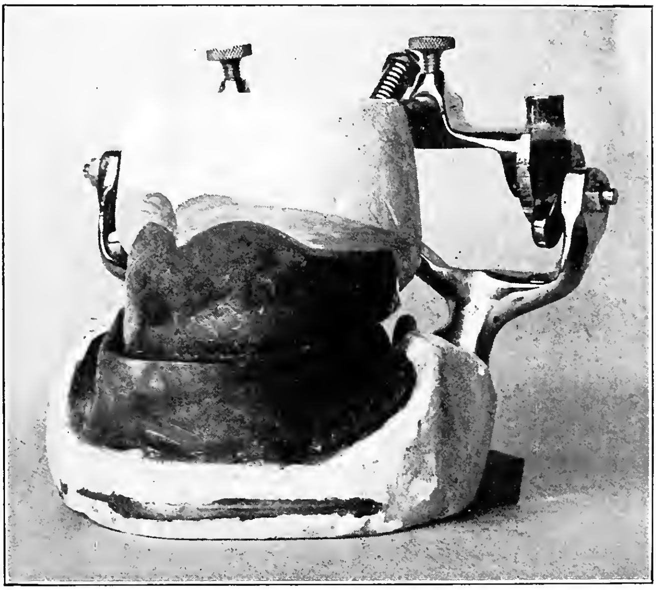
Bites in central occlusion, kept apart by built-up heel of lower. (Clapp.)

This should be built in with soft wax and the upper trial plate moistened and closed down on it. This will shape it to conform to the curve in the upper.

"If, by pressure on the same condyle slot as before, the upper model be now moved laterally, a slight separation will probably occur between the heels of the upper and lower trial plates. This is due to the fact that the upward curve of the lower trial plate was shaped by the occlusal surface of the untrimmed upper. The upper now having been trimmed, its occlusal surface occupies a somewhat different position, hence the separation. Another roll of wax is attached to the occlusal surface of the lower trial plate in the same place and in the same way as the first. The occlusal surface of the upper is moistened and the upper model

is again moved slightly toward that side and pressed down until the trial plates come in contact, on the opposite side. This will be found to again increase the height of the heel of the lower on that side and to increase also the compensating and lateral curves. The upper trial plate is again carved on that side until proper relations are established. It may now be found that when the upper model is moved laterally through the one-eighth of an inch of distance, the heels of the two trial plates will not separate. Should a separation of any size occur, it may be remedied by a third building in like fashion. By this means, the compensating and lateral curves may be so accurately worked out that no separation is perceptible between the trial plates through the range of movement mentioned. The trimming of the wax may usually

FIG. 407



The compensating and lateral curves so worked out that the trial plates do not separate. (Clapp.)

be accomplished in much less time than is here required to describe it, and with a little practice the whole operation becomes very rapid.

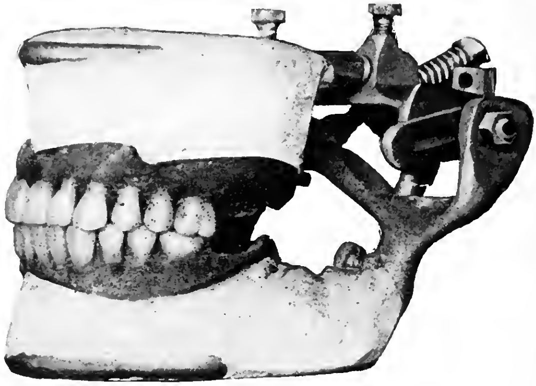
"Meantime, the opposite sides of the trial plates have remained untouched. Both sides should not be put in work at the same time. That is, if the left side is begun, it should be finished before the right side is touched. If this is not done, but both sides are put in work at the same time, the accuracy secured by the several mechanical steps here outlined will be lost. The carving will become merely time-consuming and vexatious guesswork."

Dr. George H. Wilson[1] secures a balancing of the dentures by simultaneous contact of the two sides by a method slightly different from any described so far. He says:

[1] "Dental Prosthetics," p. 240.

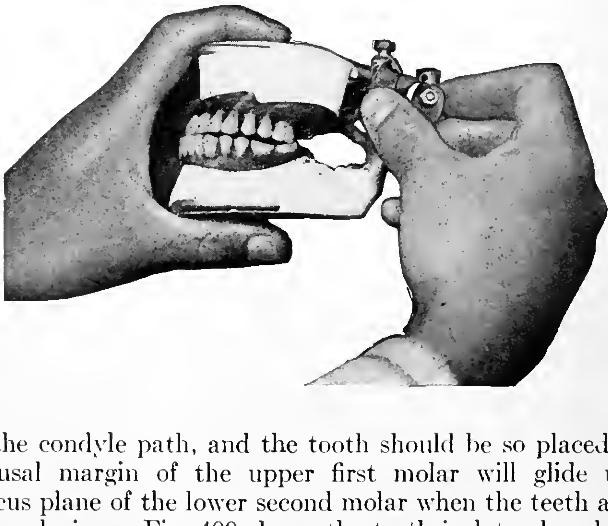
"Fig. 408 shows the twelve upper and twelve lower teeth mounted to a straight horizontal plane. Should any of the teeth be loose in their setting, they are made fast by remelting the wax about them with an ironing spatula, and the wax about all of the teeth thoroughly chilled for the next step of setting the lower second molar.

FIG. 408



"A portion of the hardened wax just back of the lower first molar is removed and a ball of softened wax set in its place. The occlusal surface of the second molar is ground into the same form as that of the first molar, and set upon the softened ball of wax. The plane of the occlusal surface of the second molar should be nearly parallel with the

FIG. 409



plane of the condyle path, and the tooth should be so placed that the disto-occlusal margin of the upper first molar will glide upon the bucco-sulcus plane of the lower second molar when the teeth are placed in lateral occlusion. Fig. 409 shows the teeth in lateral occlusion and the disto-occlusal margin of the upper first molar in contact with the

lower second molar. It is obvious that if all the teeth but the lower second molar are set in hardened wax, and it in softened wax, working the condyle joint forward and backward repeatedly will aid in properly adjusting the second molar. Correctly placing the three molars, the upper first and the lower first and second, is the key to the mechanico-anatomical antagonization; and the secret of success in the adjustment of these molars is in keeping the disto-occlusal margins of the first molars down. They may be depressed a trifle below the plane, but never elevated above the plane. Herein is the distinction between the mechanico-anatomical arrangement of artificial teeth and the variously advocated 'anatomical' arrangement of them. By observing Figs. 192 and 202 it will be seen that the anatomical arrangement of natural upper teeth is that the occlusal surfaces of all the teeth, from the central incisors to and including the disto-buccal cusp of the first molars, are in a straight horizontal plane, and that the second and third molars are not tilted, but stepped upward. So far as the author knows no advocate of the so-called 'anatomical articulation' has ever suggested reproducing this upward stepping of the second and third molars. Hence, there never has been a system of anatomical arrangement for artificial teeth, for they have all been adaptations, and all to a greater or less extent have opposed a physical law. The physical law is that 'force moves at right angles to the surface from which it emanates.' Therefore, it is evident that the system that least opposes this physical law is superior in at least this one respect. It is evident that if the molars are tilted upward at any angle (the greater the angle the greater the leverage), the closing movement of the mandible must force the upper denture forward, and that if it were not for the interlocking of the bicuspids the denture could not be retained in its place. As the first molars must assume the burden of crushing hard food, it is logical to reason that their occlusal surfaces should be parallel to their alveolar base of support. If the crushing of food were the only function of artificial dentures, then the second molars should be placed in the straight occlusal plane; however, it is important to grind the food, and to have the dentures so constructed that they are balanced in any position in which they may be occluded. To obtain this balanced relationship of artificial dentures it is necessary to have more or less of the teeth placed in harmony with the condyle path; but to secure the greatest effectiveness in crushing and grinding the food, it is necessary to have as few teeth out of the horizontal occlusal plane as possible, hence, the short balancing curve, or 'compensating curve.' This term 'short balancing or compensating curve' is in contradistinction to the long 'compensating curve,' as first taught by Dr. Bonwill.

"Having developed the philosophy of this particular arrangement of these three molars, a return may be made to the technique.

"In like manner the three molars are adjusted on the other side of the case."

TRIAL OF THE DENTURES.

Upon theoretical grounds after a set of artificial teeth has been articulated so as to have correct functional relations in the various movements of the lower bow of the articulator, they should be capable of correct functional relations in the mouth. The fact, however, that there is no articulator in existence or probably ever will be, which can absolutely perfectly reproduce the movements of the mandible in a given case, makes it advisable that after the dentures have been set up, their functional relations should be tested by actual trial in the mouth. This procedure is also desirable because of cosmetic considerations. After the teeth have been temporarily mounted, therefore, they should be tried in the mouth of the patient.

The presence of the patient will probably, even under the best circumstances, provide additional data in the matter of the arrangement of the artificial teeth. In many cases no alteration of the original arrangement of the teeth will be necessary, but this depends almost solely upon the accuracy with which the conditions related to the arrangement of the teeth have been noted and the teeth set in accordance therewith. Frequently, however, the slight alteration of the positions of some of the anterior teeth to make them more fully accord with the principles already laid down for their arrangement, will be suggested when the teeth are tried in the mouth.

The articulation of the molar and bicuspid teeth in the excursions of the mandible may occasionally require slight adjustment because of the natural limitations in articulators already noted. A systematic examination of the dentures in place in the mouth should be undertaken according to a method recommended by O. A. Weiss.[1] First, the occlusion should be carefully noted, that is, it should be observed whether the teeth of the two series occupy the same relation to each other in the occlusal position of the jaw as they did in the articulator. A possible error in the bite may be ascertained in this way. It is not enough to depend solely upon the eye to judge of this, but the actual contact of the teeth must be tested by means of a thin instrument, such as a large hatchet-shaped excavator. The patient is instructed to lightly hold the jaw in the position of occlusion. The contact of the dentures anteriorly is first tested with the excavator. If the contact is uniform, posteriorly as well as anteriorly, prying the teeth apart with the excavator should also separate the distal teeth. It must be remembered, however, that the plates are to be held firmly in their positions upon the alveolar ridges, and the operator should not be deceived by finding the plates apparently in contact posteriorly when they may be separated in front. The dentures may be detached from the membrane posteriorly, the teeth apparently being in contact, when the anterior teeth are separated by this measure. The contact of the distal teeth on both sides should be tested in a similar manner. The displacement of the dentures anteriorly by separating the posterior teeth with the excavator is not likely to occur from this procedure.

[1] The Dental Review, September, 1903.

When the distal teeth are separated, the jaws should be pried apart and the anterior teeth should also be similarly separated. This should be tested on both sides. If a serious lack of adjustment is made manifest by this trial, the bite should be retaken and the teeth reset.

In testing the relation of the teeth in the various movements of the mandible, the same general method of procedure may be undertaken. The patient is directed to move the mandible to the right and bring the teeth in contact with this position, the condyle on that side remaining in its fossa. On the right side the two lines of buccal cusps should be in contact, while at the same time the lower buccal and upper lingual are in contact on the left side. The contact is to be tested with the excavator unless it is seen that the teeth do not occupy these relations. If on the right side the cusps are not in contact, but are separated, while they touch on the left, it is evident that the cusps on the left side are too prominent or that those on the right side are not sufficiently so. This defect may be corrected by changing the inclination of the long axes of the teeth on the left, so that at the same time that the cusps on the right side are in contact, those on the left are also.

If, on the contrary, when the mandible is moved to the right, the cusps on that side are in contact and those on the left are not, the long axes of the teeth on the left should be altered so that the buccal cusps of the lower and the lingual cusps of the upper are made more prominent and come into contact. It will be evident that these alterations must be made with the plates in their place upon the articulator, and without alteration of the occlusal relations of the casts.

This operation is to be repeated with the mandible moved to the left, and any adjustment in the direction of the long axes of the teeth on either side made in accordance with the above principle.

The relation of the teeth when the jaw is protruded for incision should be tested. The patient is directed to bring the occlusal edges of the incisors into contact and to maintain the jaws in this position. The contact of the distal teeth is then to be noted, the excavator being again employed to discover if they touch. If the molars are in contact, as determined in this trial, then no alteration is to be made in the position of the teeth. If however, they are not in contact, it will be seen either that the overbite of the upper incisors is too great or that the compensating curve of the molar and bicuspid teeth does not accord with the path of the condyle. This defect may be corrected, either by reducing the overbite until the incisor and distal teeth are in simultaneous contact in this position of the mandible, or by arranging the distal teeth with a compensating curve of shorter radius.

If in the protruded position of the mandible the anterior teeth are not in contact, then the overbite is not proportioned to the compensating curve and the length of the cusps of the distal teeth: or the compensating curve has been arranged with too short a radius: or its distal end is below the line proper for the compensating curve. Adjustment of these defects may be made and the dentures returned to the mouth for confirmation of the changes.

The restoration of the facial contours and profile by the dentures should be tested at this time also and any alterations which may be indicated should be made.

THE ARRANGEMENT OF TEETH IN ABNORMAL PROTRUSION OF THE LOWER JAW.

"In the preceding illustrations and text the attention of the student has been directed to normal conditions, and the normal arrangement of artificial teeth with those conditions, in order that he may familiarize himself with the various methods and principles involved, and be able to modify them in the treatment of abnormal cases.

Fig. 410 shows an extremely abnormal relation of the alveolar ridges and one requiring a considerable modification of the usual methods in order to arrange the teeth in a manner at all satisfactory. A protrusion of the lower jaw, however, within certain limits may be met with occasionally, and a normal arrangement of the teeth obtained, providing that other conditions are favorable to it. But, before attempting to arrange the teeth in such cases, and while the patient is still at hand, the operator must make some careful observations.

FIG. 410

Showing extreme protrusion of the lower jaw, and with antagonizing casts on the anatomical articulator.

First, to ascertain whether the lower teeth can be retracted sufficiently to obtain an overbite without interfering with the movements of the tongue.

It is seldom possible to adjust the lower teeth toward the tongue further than the centre of the edentulous ridge. If such an operation is attempted, the movement of the tongue will not only be impeded and

speech impaired, but the stability of the denture will be affected by the tongue constantly pushing against it.

Second, it must be ascertained whether the tissues of the upper lip are sufficiently lax to permit of bringing the upper teeth to the necessary distance forward from the alveolar ridge to obtain an overbite.

Third, will the removal of the superior incisor teeth from the alveolar ridge cause a continual loosening of the denture by excessive leverage on these teeth?

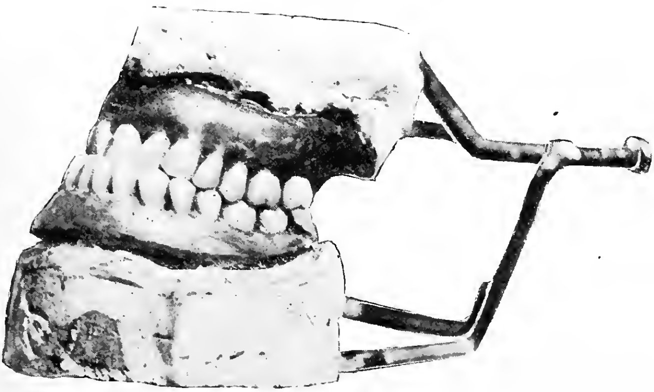
Fourth, whether the attempt to obtain a perfect profile will effect too radical a change in the patient's appearance.

Fig. 411 illustrates the arrangement of teeth necessary in case of protrusion so extensive as in Fig. 410. The upper incisor teeth are arranged to close inside of the lower, with their labial surfaces gliding closely on the lingual surfaces of the inferior incisors, the incisive function being performed in a reverse manner to that of a normal arrangement.

When the upper canine tooth is reached, the first attempt is made to merge into a normal arrangement.

This tooth is placed with its anterior cutting edge covered by the lower canine, while the distal cutting edge is turned labially and ground so as to strike directly on top of the mesial cutting edge of the

FIG. 411



Showing the arrangement of the teeth necessary in a case when the lower teeth close outside of the upper.

first lower bicuspid. The first upper bicuspid, is ground and brought out slightly more than the canine, and from this point distally the teeth assume their normal position. In order to obtain a graceful arrangement in such a case as seen in Fig. 411, it will be necessary to do considerable grinding and lapping of the upper teeth, which is not at all unsightly in this character of case.

The facial expression following such an arrangement of the teeth will be improved. In marked protrusion of the lower jaw, where the natural teeth close outside of the upper and when this condition has existed up to middle life with natural teeth, a correction of the facial expression with artificial teeth should not be attempted."[1]

[1] American Text-Book of Prosthetic Dentistry. Second Edition, p. 412.

THE ARRANGEMENT OF TEETH IN ABNORMAL PROTRUSION OF THE UPPER JAW.

In the arrangement of teeth of a full upper and lower denture in protrusion of the upper jaw, it is seldom possible to secure the ideal relations existing between the teeth of the two series when the jaws occupy a normal relationship. In most instances in which the lower jaw had a retruded position when the natural teeth were in place, after their loss, with the consequent absorption of the alveolar process, the increase in the angle of the mandible, and its forward movement, a normal relationship between the two series cannot be obtained. A few cases present themselves, however, where the placing of the artificial teeth in somewhat the same relative positions occupied by their natural predecessors is necessary. In these cases the upper anterior teeth should have a slight lingual inclination. (Fig. 412.) The lower an-

Fig. 412

Arrangement of the teeth in protruding upper jaw.

Fig. 413

Full upper denture arranged to occlude with lower natural teeth.

terior teeth should not be placed in occlusal relations with them, if it is necessary to give them a labial inclination. The lower teeth are to be made to bite upon the lingual surface of the upper plate. The molar and bicuspid teeth are to be articulated according to the anatomical principles already outlined, wherever this is possible. In every instance the cusps should be made to interdigitate, even if this requires the placing of the lower teeth the width of a cusp distal to their normal position. This condition of occlusion is frequently observed in the natural dentures.

The commonest cases of retruded lower jaw which present for treatment are those with the natural teeth remaining in position and preventing, by the nature of their occlusion, the forward movement of the

mandible. In these instances the difficulties of obtaining good occlusal relations between the teeth are greatly increased, and usually the operator has to be satisfied with an arrangement far short of the ideal.

THE ARRANGEMENT AND ARTICULATION OF A FULL UPPER DENTURE TO NATURAL TEETH.

Cases frequently present themselves for treatment in which the patient has lost all of the upper teeth, while all or a large number of the lower remain in the mouth. While the general principles underlying the articulation of teeth for full upper and lower dentures are applicable in these cases, certain additional considerations are to be noted.

When all the lower natural teeth remain, the articulation of an upper artificial set is a comparatively simple matter. One of the two series of teeth is in place; it is only necessary to arrange the other to accord therewith. While it is usually necessary to mount the casts in correct relation with the joint of an anatomical articulator which has been set according to the movement of the mandible for the case in hand, yet the necessity for so doing is not so great as in full dentures. This is because of the fact that the forms of the occlusal surfaces of the natural teeth are either in accord with the jaw movement, usually in such cases having been much worn, or if they are not, they cannot be altered, and the form of the occlusal surfaces of the artificial teeth must be largely determined by them. Still it is preferable to use the anatomical articulator, because the occlusal relations may be more certainly determined.

In the arrangement of the anterior teeth advantage may often be obtained by placing them in edge-to-edge occlusion with the lower teeth. (Fig. 413.) They are ground to articulate upon the worn edges of the lower teeth and must be made to accurately fit these edges as if they had been worn into shape in the mouth. This arrangement enhances the stability of the plate by avoiding the leverage due to an overbite, but is not possible in every case, because the distance between the lower teeth and the upper alveolar ridge may not permit the placing of a tooth of the proper size. Nor is it indeed always advisable from considerations relative to appearance. The arrangement of the artificial teeth with an overbite is demanded in such instances, but the overbite should be as short as possible. Where the lower jaw occupies a retruded position, however, it may be necessary to have a long overbite with a lingual inclination of the upper teeth, but in such instances, a firm retention of the upper plate should be assured and a space left between the upper and lower teeth to avoid displacement of the upper denture.

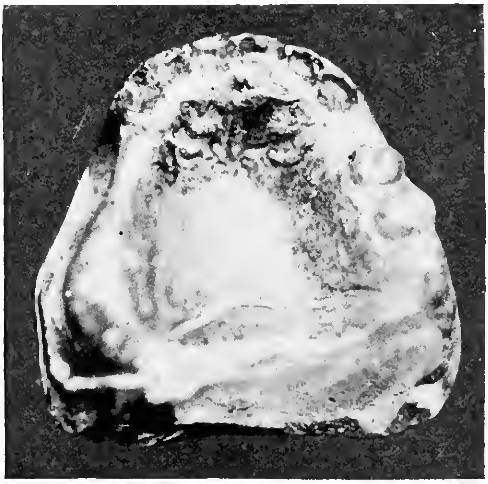
The molar and bicuspid teeth should be ground to correspond to the state of wear of the natural teeth and should be made to occlude evenly upon them. Many dentures of this type are seen in which the teeth have been articulated without alteration of their form, the long sharp cusps

of the artificial teeth occluding upon much abraded lower natural teeth. The functional disadvantage of such an arrangement is manifest.

Where only the lower anterior teeth remain, and these cases are of common occurrence, the principles already laid down for the correct articulation of the artificial teeth may be followed out almost completely. It will be remembered that the lower anterior artificial teeth in full dentures are the last ones to be placed in position. In the case under consideration the natural teeth serve as a starting point in the arrangement of the artificial teeth, which latter may be made to accord with the former. The slight settling of the lower partial denture should be borne in mind and anticipated by arranging the upper teeth just short of occlusion with the natural organs.

This type of case illustrates particularly well the necessity for complete restoration in every case which presents itself. In these instances if the lower partial denture is not made, the whole function of mastication is thrown upon the natural teeth and the upper plate. In the course of time the pressure upon the anterior portion of the upper plate will

Fig. 414



A cast showing recent extraction of six anterior teeth.

cause an absorption of the alveolar process underlying it. The mucous membrane in the anterior part of the upper jaw will become soft and spongy and re-adaptation of the plate may be necessary. This latter procedure will be complicated by the softness of the tissues over the absorbed process, and it will be difficult to obtain satisfactory results. On the other hand, if a lower partial denture had been inserted, the condition alluded to would have been avoided.

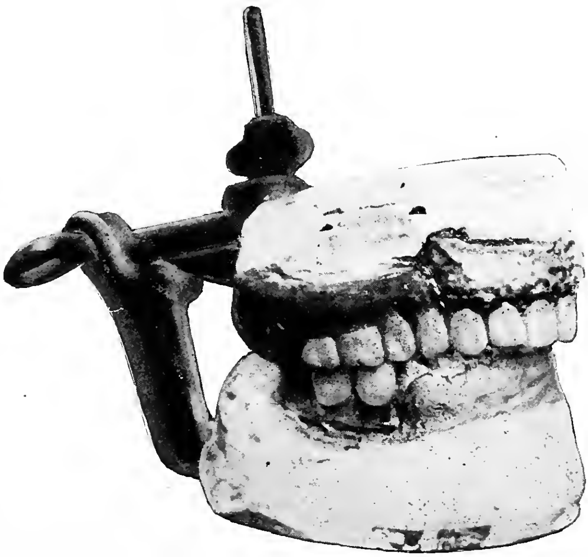
TEMPORARY DENTURES.

While in the strictest sense of the term all dentures are temporary, as greater or less change is constantly going on in the process, reference is

here made to dentures inserted within a short time after the extraction of the teeth. Temporary dentures are to be advised in every instance in which there is not some contraindicating condition. They may be inserted either immediately after the extraction of the teeth before the inflammatory reaction incident thereto has subsided, or they may be inserted after the inflammation has ceased and before the resorption of the process has appreciably progressed. They serve to provide the patient with a masticatory apparatus and avoid a period in which the patient is seen without teeth.

The selection of teeth appropriate for these cases has already been discussed. If it is desired to insert the plate immediately after the extraction of the teeth, an impression must be taken and a cast made with the natural teeth *in situ*. The plaster teeth are then cut from the cast, which is carved to represent the conditions after the teeth shall have been extracted. The anterior artificial teeth are to be mounted in the

Fig. 415



Showing the arrangement of teeth necessary in a case like Fig. 406, where the six anterior teeth were recently extracted.

sockets of the natural ones. The cast is carved to permit this. Anticipating to some degree the absorption of the external plate of the process, as shown in Fig. 414, the artificial teeth are to have the portions which are to be in relation with the cast so ground that their necks project into the socket, and yet after the external plate has been absorbed, they will be in relation with the labial surface of the process. The distal teeth are to be mounted in the usual relation with the alveolar ridge. The buccal portion of the plate is to be made as for full dentures, but should not extend farther forward than the centre of the first bicuspid. Of course no portion of the plate is to extend over the unresorbed process anteriorly. (Fig. 415.)

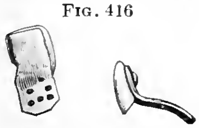
PARTIAL DENTURES.

After the teeth for partial cases have been selected in accordance with principles already outlined, they are to be adjusted in their proper position on the cast. It will be seen that there is less latitude in their arrangement than exists in full cases, yet their correct positions with reference to the natural teeth which remain may be more readily determined. All that has been said concerning the arrangement of teeth to give the most natural appearance applies to some extent to the setting of teeth for partial dentures.

In the anterior part of the mouth, gum or plain teeth are to be used according as there is necessity for a restoration of lost gum tissue or not. Before the teeth are placed in position, the cast, in relation to which they are to be placed, is to be scraped, so that when the appliance is put in the mouth, these teeth will press upon the mucous membrane and imbed themselves slightly in it. The gum of gum-section teeth is to blend with the natural gum, while plain teeth are to be made to appear as if growing from the mucous membrane. The teeth are, therefore, to be ground to accurately fit the cast. This procedure requires considerable care to see that the teeth touch the cast uniformly. The use of carbon paper placed between the cast and the tooth will greatly facilitate the process by indicating the points to be ground. Nothing short of an accurate adaptation of surface should be accepted. It is usually wise to anticipate the resorption of the process in the front of the mouth under a single tooth and to mount it on the cast slightly longer than its neighbors with this in view. In the settling of the plate, which occurs within a short time, the tooth is made of correct length.

In those portions of a partial denture where gum restoration is to be made, and where the artificial teeth do not rest upon the mucous membrane, the same principles which apply to the placing of teeth for full dentures obtain. Where the partial plate carries more than a few teeth, the setting of the casts upon an anatomical articulator and the articulation of the teeth according to methods already described, are indicated. In every instance the artificial teeth are to be ground so that they correctly occlude with their opponents. In the trial of the artificial dentures in the mouth the relation of the teeth in the several positions assumed by the jaw in mastication is to be tested, and where a cusp interferes with a gliding contact of the teeth, alteration is to be made.

Fig. 416



Teeth for close bite.

In the few cases in which it is deemed advisable to open the bite, it is necessary to provide for the contact and correct functioning of the natural teeth which have thus been separated. Where these are molars and bicuspids, they should preferably receive crowns whose occlusal surfaces should be made to accord with the line of occlusion of the teeth on the plate. This may be best done by preparing them for the crowns, and after the latter have been constructed and temporarily put in place,

the bite is taken with the jaws in their new position. The crowns are removed and may be permanently set when the denture is inserted.

Where the bite is very close in cases in which the natural teeth almost touch the opposing gum, special arrangement must be made to secure sufficient strength for the artificial teeth in this location. Where the denture is to be of vulcanite and sufficient space exists for a reasonable thickness of the plate, the use of a long bite tooth is indicated. If, however, only one tooth is to occupy the space under such conditions as this, it is preferable to use a plate tooth to which is soldered a backing with an extension as shown in Fig. 408, which is imbedded in the vulcanite. This gives more character and strength than if a vulcanite tooth were used. If the plate is to be of metal, the tooth is, of course, directly soldered to it.

II. VOICE AND SPEECH RELATIONS.

It is desired that artificial dentures shall restore any lost portions of the apparatus necessary in the production of articulate speech, and, in addition, shall offer no impediment to the normal articulation of sounds. It is desired also that they shall produce the least possible alteration in the tones of the voice.

It has been seen in Chapter IV. that the loss of the teeth and the changes in the surrounding tissues incident thereto, cause but slight alteration in the quality of the voice, that speech is chiefly affected by these conditions, and that the production of the vowels is less affected than the production of the consonants. It was seen, further, that the chief alterations of conditions affecting consonant production are the loss of the tissues upon which the current of air is projected, or of those at the site of which the current of air is stopped, and the loss of tissues concerned in the formation of the channel through which the air is forced. It is with the remedy of these conditions that we are chiefly concerned, and at the same time the artificial denture must be designed to offer the least possible impediment to the articulation of all sounds.

Slight alterations of the tones of the voice will occur when any artificial denture is placed in the mouth of a patient. These are, in many instances, so slight as to be indistinguishable, while in others the difference may be sufficient to be appreciated. This consideration, however, is of comparatively small importance in the design of dentures, for the reason that it is impossible to place an appliance of any sort in the mouth without producing some slight changes in the voice tones. Thinness of the plate which covers the palatal vault contributes more than anything else to a retention of the normal voice qualities. It is for this reason that the swaged metal plate causes less change than a plate of one of the molded bases.

In designing a denture to fulfil all the requirements of speech the following fact must be noted: the factors concerned in the speech relations of a denture are the form, location, and arrangement of the

teeth, and the lingual conformation of the upper and lower dentures. These factors are to be so adjusted to the case in hand as to permit a free movement of the tongue, and the correct formation of the air channel, and provide for the obstruction of the air current at the proper places.

Fortunately the form and arrangement of the teeth to answer the requirements of appearance and food preparation, in general, best serve the ends to be desired from the standpoint of speech production. There are a few exceptions to this principle which are to be noted. The arrangement of the upper and lower anterior teeth with a slight space between them to prevent contact and consequent displacement of the denture, recommended by some practitioners, interferes occasionally with the articulation of the sounds in which the current of air is interrupted at this point. The tongue is called upon to close up the deficiency caused by a lack of contact of the teeth in the production of the sound, for example, an adjustment which it is usually possible for it to execute.

The bicuspids and molars for considerations of plate stability frequently intrude upon the space required by the tongue in its adjustments; a consequent cramping of this organ occurs with a certain thickness of speech which persists until the individual has adapted himself to the abnormal conditions.

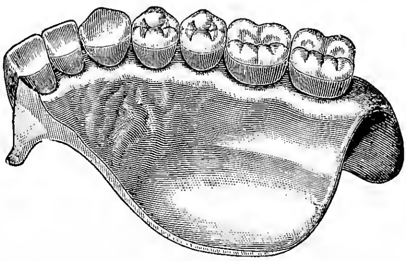
Freedom in the movement of the tongue may some times be prevented by an impingement of the plate upon its frænum. It has already been seen that this condition is to be avoided upon another ground—that of the displacement of the denture.

A common error in the conformation of the lingual surface of lower plates causes a limitation to the movement of the tongue. Where the lower molars and bicuspids are placed to the lingual side of the ridge to occlude with those of the upper jaw in mouths in which great resorption of the process has occurred, the narrowness of the plate restricts the tongue movements necessary to correct articulation. It not infrequently happens that the lower plate itself intrudes upon the space proper for the tongue. These conditions are to be avoided if possible. It is often necessary to compromise the demands of plate stability with those of speech production. This situation arises in a large number of lower dentures constructed for mouths in which considerable resorption of the process has occurred. In these instances the arch of the teeth should be as wide as is consistent with plate stability, and at the same time the lingual surface of the lower plates should be made as concave as possible to provide adequate space for the tongue.

When the lingual conformation of the upper plate copies as accurately as possible the form of the natural tissues, the conditions most favorable to articulation are established. Large numbers of vulcanite dentures are made with a smooth dome-shaped lingual surface, to which the tongue can adapt itself in the formation of the air channel with less ease than if the conformation of the natural tissues were reproduced.

In the formation of the TH, T, D, S, SH, C, Z, ZH sounds, the sides of the tongue are curled up to come in contact with the teeth and adjacent alveolar process to form the channel through which the air escapes. It has been seen that the form of this channel largely determines the consonant sounds. While the tongue can adapt itself to changed relations of other tissues taking part in the formation of this channel, as the enunciation of patients wearing dentures constructed regardless of these conditions abundantly testifies, yet it is not wise to impose too much upon the tongue in this way. The more nearly the lingual surface of the plate corresponds to the form of natural tissues, the more readily will the tongue be capable of affecting correct adjustment to them. With this end in view it is advisable in vulcanite dentures to reproduce the lingual surfaces of the teeth, either by the use of counter-sunk pin teeth or by the imitation of these surfaces with the vulcanite.[1] (Fig. 417.) The imitation of the rugæ on the lingual surface is to be referred to presently.

Fig. 417



Lingual surfaces of teeth reproduced in vulcanite. (Fine.)

The projection upon the lingual surface of a metal plate caused by the vacuum-chamber seldom interferes with correct speech production. This is for the reason that if properly located and of only the required depth, it does not prevent the formation of a sufficiently large channel for the air. The tongue, of course, has to adjust itself to this condition of affairs, but the adjustment is made with comparative ease. Furthermore, if properly located, the vacuum-chamber is posterior to the point of interruption of the air channel in the formation of the T, D, S, C, Z, SH and CH sounds.

The conformation of the lingual surface of the upper plate to facilitate correct speech has been well described by Dr. George B. Snow. The following is requoted from a paper published in the Dental Advertiser in 1899. "Trouble is often experienced by patients in securing a clear and sharp S sound after they have commenced the use of artificial dentures. A peculiar whistling sound is produced. It is now proposed to give a short description of the mechanism by which these sounds are produced, and to draw attention to the importance of giving

[1] Dr. W. M. Fine, International Dental Journal.

due consideration to the shape of the lingual side of the plate, if it is desired to secure clearness and ease of articulation of the sound above referred to.

Inspection of models of the upper jaw in which the natural teeth are in place will show that while the lingual surface of the bicuspids and molars practically forms a continuation of the lateral curve of the palatal arch, the alveolus behind the incisors is thickened. With the rugæ a nearly triangular space is oftened produced, bounded by a line connecting the distal surfaces of the laterals and the edges of the alveolar sockets. Viewed in longitudinal section, a reversed curve is presented, extending forward from the hard palate and merging into the hollow outline of the lingual surfaces of the incisors.

Sections of models from different mouths are shown in Figs. 418 to 423. The curves will be seen to present nearly the same general shape, whether the arch be deep, like Fig. 419, or shallow, like Fig. 421.

Fig. 418

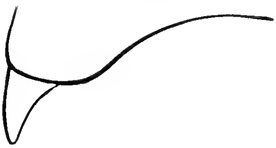


Fig. 419

Fig. 420

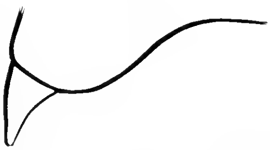


Fig. 421

Sections through casts showing thickened alveolus back of incisors.

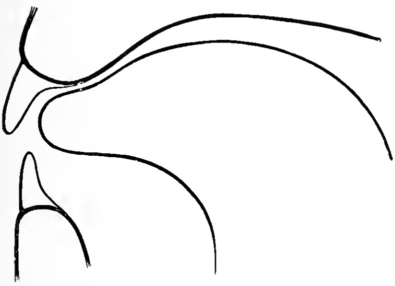
In Figs. 422 and 423 an attempt has been made to show the relative positions of the tongue and teeth in making the S and SH sounds. In producing the SH sound (Fig. 423), the upper and lower teeth are held slightly apart; the tip of the tongue rests against the gum behind the lower incisors, its edges impinging upon the lingual surfaces of the bicuspids and molars at their junction with the alveolus. The result is a narrow passage over the centre of the tongue, the narrowest portion being just back of its tip, the passage being thus gradually enlarged both behind and before its narrowest portion. The breath, being forced through this narrow passage, follows its curve, and is impelled against the tips of the lower incisors, the result being the SH sound.

In giving the S sound (Fig. 422, all the parts remain in the positions above described, except the tip of the tongue, which is curved upward to the alveolar border on the lingual side of the upper incisors, making the passage smallest at its outlet and projecting the current of air against the upper incisors. It will be found by experiment that if the tongue is drawn backward a little from the position described, the his-

sing sound will be changed to a whistle. It will be noticed that the shape of the palatine arch is such that the tongue can readily conform to it, and that the passage between the tongue, palate, and alveolar border can be readily formed, by which a clear articulation of the sounds in question can be produced.

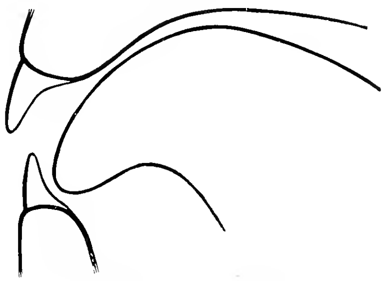
As a contrast to the figures already shown, attention is directed to Fig. 424, which is a section of a fairly well made vulcanite plate. The teeth are well arranged, the joints close and well fitted, the finish good.

Fig. 422



Position of tongue in pronouncing S.

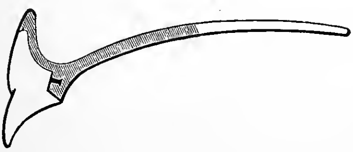
Fig. 423



Position of tongue in pronouncing SH.

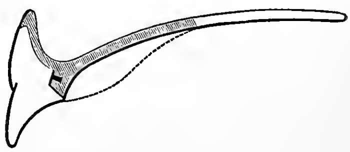
It will be observed that the palatal curve, if continued, would meet and coincide with the curve of the lingual surfaces of the incisors, there being a break at the point of junction of the teeth and rubber; and this is so abrupt that it would be impossible for the tongue to follow its outline, as it does the curve of the natural arch in Figs. 422 and 423. The reversed curve, shown in Figs. 418–421, is plainly out of the question. The sketch illustrates what is by no means an extreme case. With thinner teeth and a longer bite the defect noted would be still greater.

Fig. 424



Section through vulcanite plate.

Fig. 425



Section through vulcanite plate designed to imitate contour of alveolar process back of incisors.

If the plate which is shown in section in Fig. 424 were filled in to present the outline shown in a dotted line in Fig. 425, the enunciation of the wearer would be improved, and another very substantial benefit be secured, viz., an amount of strength which will obviate any danger of the plate cracking through the centre.

If the imitation of nature be carried far enough to reproduce the rugæ upon the plate, it will be found to be a decided benefit both to articulation and in the management of food in mastication. When the lin-

gual side of the plate is smooth, the tongue has but little power to hold a morsel of food upon it, while with the rugæ the food is easily held and managed. They are easily formed by burnishing a piece of heavy tin foil over a model showing them prominently, filling the depressions in the tin foil with wax or paraffin, and then fitting and attaching it to the trial-plate when waxed up and ready for flasking, leaving its edges turned up so that it will be held securely in the plaster when the plate is flasked. The surface of the vulcanite will come out clean and smooth, and will require but little polishing. It will be found that a patient who has once become accustomed to the use of a plate made as above suggested will be extremely loath to return to the use of one as ordinarily made."

III. THE RELATION OF PLATE DENTURES TO THE EXPRESSIVE MOVEMENTS OF THE FACE.

Beside restoring the fixed expression of the face, plate dentures must establish conditions which admit of the normal activity of its expressive movements. It has been shown in Chapter IV. that the following conditions resulting from the loss of the teeth affect these movements: a change in the relation of the jaws and the withdrawal of the normal support provided by the teeth and alveolar process for the lips and cheek; the restriction of the movement of the lips and cheeks in the associated group of muscular movements which give expressional significance to the face. Artificial dentures are to establish such conditions as will permit the normal operation of these movements.

In the design of the dentures to answer the above mentioned requirements, the following factors are to be considered as promoting the desired ends. The relation between the jaws is established in the position of occlusion by the dentures. The support of the lips and cheeks is furnished by the positions of the teeth and the contours of the buccal and labial surfaces of the plates.

While the correct operation of the muscular activities concerned in the expressive movements in which the mouth participates, is largely provided for, if the dentures answer other requirements imposed upon them, it is necessary to call attention to the features of the dentures directly concerned in this relationship, in order that in the promotion of other purposes these considerations shall not be infringed upon. As with natural dentures, the lips should be capable of free and easy movement over the teeth and the labial surfaces of the plates. The margins of the dentures and its external contours should not encroach upon the line of action of any of the muscles concerned in these movements. The labial contours of the plates and the teeth should support the lips in those positions which are subsequently discussed as proper for the establishment of the fixed expressions of the face. They should permit an easy gliding of the lips over them upon the contraction of the various muscles centering in the orbicularis oris.

The upper plate is the one mostly concerned in this relationship. Its upper margin should not impinge upon the attachments of the orbicularis oris in the incisive fossæ. At the position of the canine tooth there should be enough of a prominence to afford a *point d'appui* for the muscles elevating and retracting the corner of the mouth. The upper margin of the plate should not be so thick as to prevent a direct line of action in the elevation of the lip by the levator labii superioris alæque nasi and the levator labii superioris proprius.

The lower denture should avoid in its anterior margin the line of action of the levator labii inferioris, which is placed to the side of the median line of the symphysis.

An incorrect relation between the jaws would, of course, cause a limitation of these movements, if the distance established was too great or too small, and too great or too little prominence to the plates underlying the lips would cause a similar limitation to the expressive movements of the mouth. It will, of course, be seen that the conditions necessary for the correct operation of the movements concerned in expression, have been provided for by other considerations relative to the dentures. These several demands have overlapped in this particular and the necessity for the correct construction of the dentures is, therefore, increased.

IV. THE RESTORATION OF FACIAL EXPRESSION.

The alteration in facial expression which succeeds the loss of the teeth has been described in Chapter IV. One of the chief functions of artificial dentures is to restore this. By the insertion of artificial dentures the relation between the jaws should be correctly established, the contours of the lips and cheeks restored, and the teeth and those portions of the gum visible in the movements of the lips restored as nearly as possible to their original appearance. The various steps in the design and construction of the dentures which have already been described have served to promote these ends.

The relation between the jaws in the position of occlusion is established when the bite is taken. At this time also a tentative fulness which the plates should possess to restore the lips and cheeks to their original contours, is obtained. In the arrangement of the artificial teeth the portions of the dentures visible in laughing and smiling are arranged so that the teeth correctly harmonize with the other features of the face. The court of final resort in determining the efficacy of these several measures should be the actual trial of the dentures in the mouth. It is now proposed to discuss the various details of the dentures which are related to the restoration of facial expression.

The primary object which artificial dentures should have from the cosmetic standpoint is the establishment of the appearance which the patient would have if the natural teeth had remained. This is, of course, however, subject to the slight exceptions which have already

been mentioned in this chapter, but in the main, this is the purpose in view. It has already been shown that complete data for the execution of this motive are lacking in nearly every instance. The circumstances most favorable for the exact establishment of such a condition are the recent extraction and preservation of the teeth of the patient for reference, and the possession of photographs taken shortly before the teeth were lost. Even to these data must be added an allowance for the effects ensuing, if an appreciable period has elasped between the restoration and the time to which the original data referred.

For the most part the restoration of appearance must be undertaken with data secured at the time the dentures are made, which are the only source of reference. These data are to be obtained almost solely from the patient. They may be occasionally supplemented by reference to other members of the family of the patient, whose physical similarity so corresponds as to make their use of service. A brother or sister, for example, or a son or daughter, may sometime be possessed of characteristics resembling those of the lost tissues of the patient which will furnish reliable information in these particulars. The accuracy of this resemblance should be positively ascertained before it is utilized for this purpose. Some general considerations relating to the restoration of facial expression may not be out of place.

While the majority of faces which require restoration by prosthetic means cannot by any artifice be made to correspond to the regular conditions of profile and contour established by the ideals of art, yet these latter should be a possible goal, nearness of approach to which is only limited by the particular conditions found in the individual case. The attainment of this ideal is neither to be hoped for nor expected, because of the natural limitations which the conditions of each case impose. In the lack of definite information as to the conditions originally existent in the individual case, the effort should be to exhaust the information furnished by the tissues as to the original condition, and then to complete the restoration along lines consistent with the artistic ideals.

The student will find the following quotation from John W. Vanderpoel's "Drawing and Construction of the Human Figure"[1] of value in arranging the contours of the lips, and should read it in connection with Figures 426 and 433, which illustrate a patient with correct facial contours established by a full upper and lower denture. He says, "Beginning with the front view, note the convexity of the mass of the mouth as affected by the teeth; this means that as the corners are farther back than the middle, the curvature of both lips in their approach to the corners partakes of foreshortening. Irrespective of the view, establish the relation of the corners to the middle. This is exceedingly important, as it relates to symmetry in its construction and action, as well as to expression and character. In a normal mouth the corners are slightly lower than the middle, Though the mouth is convex in the mass (except at the corners where the lips dip into a

1 The Sketch Book, July, 1903. p. 25.

depression), it is differently expressed in each lip. The mucous portion of the upper lip is divided into two equal parts or planes, of greatest width in the middle, retreating in diminishing thickness with a downward course to the depressed corners. The lower lip on the other hand contains three planes, the central one extending well on each side of the middle of the upper lip, and flanked by a minor one on each side, rising to an acute angle at the corner. The planes of the upper lip are comparatively flat, while those of the lower are very convex.

The length of the upper lip has its origin at the middle cartilage of the nose in the form of a depression, which widens as it descends, and terminates in the delicate angle of the middle of the upper lip: the centre of this angle forms the most forward part of the mouth. This

Fig. 426

Profile view of correct facial contours established with artificial dentures

angle is repeated in the contact of the upper lip with the lower immediately below this point, although the angle is more obtuse and a little flattened, showing how the upper lip clasps the lower as it overhangs it. The lower lip rolls outward and is apt to be full and convex in proportion as the concavity below it is deep. This depression or length of the lower lip divides perceptibly and forms at its base the upper border of the chin. Through a study of the profile, which is equivalent to the section, these facts are more easily understood. Note first the backward sloping plane from the nose to the base of the chin, and in it find a series of steps, the upper lip overhanging the lower and the lower the chin. Note the concavity in the length of both lips, and the convexity of their breadth or mucous portion, greater in the lower—at least more rolling—all subtly connected with the adjacent parts of the face, particularly in the soft play at the corners." . . . .
"However the student must fully realize that no matter how intimate

his knowledge of a part may be, it is only of value when it coëxists with an appreciation of its relation to the entire structure."

The regular profile above described is that obtaining only with individuals the antero-posterior relation of whose jaws produces it. As the prosthetist has no control over the antero-posterior position of the mandible in his restorations, it is only in the cases in which this is normal that he may attempt to establish the relation of the lips which is shown to be harmonious with such a jaw relationship. He should take note, however, of the commonly observed principle of profile that a projection of the lips, which is caused by a projection of the teeth and process, is commonly associated with a receding forehead, and that in those individuals possessed of a more marked development of the

Fig. 427

Front view of patient with full upper and lower artificial dentures in place showing restoration of facial contours. Same patient as in Figs. 225 and 226.

Fig. 428

Profile view of patient showing restoration of facial profile. Same patient as in Fig. 225 and 226.

frontal region in which the facial angles are more nearly approximate 90°, there is less protrusion of the lips.

The conditions of contour of the lips affecting the profile commonly observed in individuals with the jaw anterior or posterior to the above described relationship, should be observed. A common type of face observed in America is that with a retruded chin. In these cases the positions of the lips are altered from that above described to accord with such a position of the mandible. This type of face is shown in Fig. 430. It will be seen by reference to this figure that the lips occupy approximately the same relation with a line drawn from the base of the nose to the chin as they occupy in Fig. 426. In all cases where the jaw occupies this position this relation of the lips should be obtained. The upper lip must frequently be made slightly more promi-

nent, but this only to be done when the contours of the alveolar processes demand it. (Figs. 429 and 430.)

Cases are of less frequent occurrence in which the mandible is protruded. In an edentulous case of this character, beside the observed relationship between the alveolar processes, the prominence of the cheek over the ramus of the jaw contributes to aid in the diagnosis. In such instances the curves of the lips observed in cases with a normal jaw relationship do not exist. This is because of the nature of the support afforded the lips by the process and the differently inclined teeth and because of the muscular action which has been necessary to keep the lips closed. In such instances, therefore, the prosthetist can only, of course, hope to establish conditions of profile which were as good as those existing before the loss of the teeth.

Fig. 429

Front view of patient with full upper denture in place, showing restoration of facial contours

Fig. 430

Profile view of patient with retruded chin: full upper artificial denture in place.

At the age at which artificial dentures are commonly necessary the full and rounded contours characteristic of youth have usually faded. In individuals of this age who have not lost their teeth these effects are likewise observable. The prosthetist, therefore, should take into account in his restorations the effect which age produces upon both profile and contours, and should establish these in accordance therewith. A patient exhibiting the effects of the passage of time upon other fixed features of the face, yet displaying oral contours belonging to a previous period of life, would be an inexcusable anomaly.

The effect of age in the absorption of the subcutaneous fat, in the atrophy of the skin, and the establishment of wrinkles in the face, has been described in Chapter IV. No attempt, therefore, in the pros-

thetic restoration should be made to alter the conditions clearly attributable to this influence. The lines about the mouth, for example, which have resulted from age, are not to be altered, while those which have ensued from the loss of the teeth are to be corrected as far as the prothetist is able.

Finally, the prothetist should utilize every minutia of information to be obtained from the patient and from the conditions of the tissues about the mouth. A full knowledge of the influence of time and of the influence of the loss of the teeth should be in his hands, and his efforts should be directed toward the re-establishment of conditions, alteration of which has produced the observed changes.

Fig. 431

Full upper denture with elongate centrals, slightly inclined lingually. Same patient as Figs. 429 and 430.

Fig. 432

Patient with full upper denture: incisors irregularly arranged.

In discussing the details of the restoration of the contours of the mouth and cheeks, simplicity will be consulted by considering first the profile and then the contours of the face as viewed from the front. In establishing the profile in accordance with the principles above outlined the following factors are to be taken into account: first, the relation of the jaws. This is determined tentatively at the time the bite is taken, concerning which it was said, that such a distance should be established between the jaws and such a fulness of the bite-plates provided, that the lips rest in contact without restraint and display an equal amount of mucous membrane. Although the contact of the lips in the manner described as desirable, is influenced both by the distance between the jaws and the fulness of the bite-plates, these two factors should have been so adjusted that the amount of protrusion of the lips desirable in the case in hand is obtained. If this has been satisfactorily done and

dentures constructed to accord with the forms of the bite-plates, no alteration in the distance between the jaws will be necessary.

The base of the upper lip, in relation with the nose and the upper part of the face, is fixed. The chin and tissues up to a point opposite the point of reflection of the mucous membrane of the process to the lower lip are also fixed. The amount of outward inclination of the upper lip, its curve, the amount of mucous membrane displayed, the position of the lower lip, as related to the upper, and the sulcus mento-labialis are the factors which may be adjusted. The thickness of the lips is another factor which may be in some part taken as an index of their position, thick lips being usually associated with an outward inclination of the teeth and a projection of the lips, thin lips being usually associated

Fig. 433

Full face, showing good contours and lines.

with a less prominent position. For the most part the line from the base of the nose to the margin of the mucous membrane of the upper lip is approximately a straight line. It is curved inward where the margin of the lip is prominent, the curve being due to the difference in thickness of the lip at this point, and not to the conformation of the supporting structures beneath. Where the lower jaw occupies a distal position, the lip may be either in a vertical line, or may be slightly inclined backward.

The sulcus mento-labialis, which imparts considerable beauty to the form of the lower lip, is caused by the greater thickness of the margin of the lower lip, by the contact of the upper anterior teeth with its upper surface which serves to roll it slightly outward, and by the intimacy of attachment of the skin of the chin to the mandible. This curve is to be established, if possible, but where great absorption of the fat has occurred,

or in some cases from an original disposition of the parts, this is not possible.

The amount of mucous membrane displayed by the two lips should be equal in cases with a normal relationship of the jaws. In individuals with a retruded lower jaw more of the mucous membrane of the upper lip will be displayed than of the lower. Where the lower jaw is protruded, there is likewise a corresponding difference in amount of membrane visible.

Viewing the face from the front the following points are to be noted: the line marking the point of contact of the two lips. This is affected by the natural configuration of the lips, by the distance between the jaws, and by the amount of projection of the structures supporting the

Fig. 434

Continuous-gum denture showing contours. (Wilson.)

lips Unfortunately, at the age at which plate dentures are necessary the fine lines characteristic of youth are frequently so altered that the establishment of these lines in their most beautiful form is impossible. Of course the original condition may have been such that this is not possible. The ideal cupid's bow, shown in Fig. 433 is that to be sought in all cases, but ordinarily only a straight line of separation may be obtained. This should preferably occupy a horizontal plane as it does usually in the natural condition, although cases are frequently seen in which the distal ends of the line are at a lower level than the middle. This latter condition may be produced if the jaws have been established too close together. Where it existed originally, of course, no improvement can be made.

The philtrum is frequently obliterated by the falling in of the tissues after the loss of the teeth, if age has not already had this effect. The prosthetist, probably, has no influence over the formation of this groove, other than if the lips are put upon too great a strain, it may be further obliterated. The same may be said of a prominent tip or tuberculum of the upper lip. Both age and the loss of the teeth serve to straighten the line of separation between the lips and obliterate this

prominence, while in those cases in which this effect has not ensued, the tuberculum should be preserved by imposing no great strain upon the lips.

The canine eminence will usually require considerable restoration with the artificial dentures, because of the large amount of absorption of the process which occurs at its site. The temperamental type of the individual will assist in affording information in determining the amount of building to be undertaken at this point. Individuals of the bilious temperament and its various combinations will require prominent canines and prominent portions of the plate overlying this tooth. In the individual case reference should be made to the naso-labial fold, which is usually accentuated both by age and the loss of the teeth. Ordinarily it extends from the base of the ala of the nose with decreas-

Fig. 435

Wax model of denture with extensive contours.

ing depth to a point slightly below the corner of the mouth. The building out of the canine eminence will increase or decrease this fold by elevating the lips to the level of the cheek tissue adjoining the upper margin of the fold. In determining the fulness to be established here, reference should also be made to the already established inclination of the centre of the lips.

In instances in which the wrinkles radiating from the mouth and caused by loss of the teeth have been of long standing it will be impossible to eradicate them by the placing of the denture. Much improvement will occur after the use of dentures properly restoring the contours, but immediate correction of the defects in the surface of the skin cannot be expected. This is also true of the groove frequently observed descending from the angle of the mouth toward the chin, but the plates should remove these wrinkles as far as possible.

CHAPTER XIII.

VULCANIZED RUBBER AS A BASE FOR ARTIFICIAL DENTURES.

By George H. Wilson, D.D.S.

Vulcanite.—A chemical compound of Caoutchouc and Sulphur.

CAOUTCHOUC.

History.—Caoutchouc is a native Indian name. India-rubber is a name given the material because its early use in Europe was to remove black lead pencil marks from paper. Dr. Priestley, the distinguished discoverer of oxygen, mentions this use in a publication of 1770. Caoutchouc must have been known in America at a very early period, because balls made from the gum of a tree, lighter and bounding better than the wind-balls of Castile, are mentioned by Herrera when speaking of the amusements of the natives of Haiti, in his account of the second voyage of Columbus. In a book published in Madrid, 1615, Juan de Torquemada mentions a tree which yields it in Mexico, describes the mode of collecting the gum, and states that it was made into shoes. More exact information was furnished by a French Academician, who visited South America in 1735. While the Indians used it more than three hundred years ago for water bottles and gum shoes, it was only used in the United States and Europe for erasing pencil marks, until about 1820, when it was applied to water-proofing cloth. As caoutchouc became hard and brittle in cold weather and sticky in hot weather, many experiments were made to overcome this objectionable quality which resulted in the discovery of vulcanite in 1843.

Physical Properties.—Caoutchouc is the dried milky juice of various trees and plants. A similar gum capable of vulcanization can be obtained from the common milk-weed and other plants of temperate climates, but it is only commercially profitable from certain trees in the tropics. The Brazilian, or Para (a shipping-port on the Amazon river) caoutchouc is the product of several species of Siphonia (nat. ord. Euphorbiaceæ), chiefly Siphonia elastica. Bates says that this tree is not remarkable in appearance; in bark and foliage it is not unlike the European Ash, but the trunk, like that of all forest trees, shoots up to an immense height before throwing off branches. The India-rubber produced in New Granada, Ecuador and Central America is obtained from Castilloa elastica ; that of East India from the beautiful glossy-leaved Ficus elastica, now a common ornamental plant in conservatories; that of Borneo from Urceola elastica; and that of West Africa from several species of Landolphia and also Ficus.

After the trees are tapped, the juice is first received in clay basins, and then is solidified in various ways—as by spreading it out in thin layers and evaporating in the sun or by the aid of artificial heat; or the emulsion is coagulated by the leaves of a kind of vine—a method used in Central America which gives, however, a product inferior to that obtained by evaporation. The evaporated product is known as "biscuit." The fresh juice has the consistency of cream, is yellow, miscible with water, but not with naphtha or other solvents of ordinary rubber; its specific gravity is 1.02—1.41; the yield of the gum is about 30 per cent. Pure caoutchouc is devoid of odor and is nearly white; it has the specific gravity of .915. The finest quality of caoutchouc is that from Brazil (Para) which has the least impurities; the other South and Central American kinds are of medium quality; East India rubber ranks next, while the African rubber is quite inferior.

Commercial India-rubber is a dark, tough, fibrous substance, possessing elastic properties in the highest degree. At the freezing point of water it hardens and largely loses its elasticity. The gum is insoluble in water or alcohol, and is not acted upon by alkalies or acids except when the latter are concentrated and heat is applied. It is soluble in ether, chloroform, bisulphide of carbon, naphtha, petroleum, benzol, and the essential oils, and in many of the fixed oils by the aid of heat. Caoutchouc melts at a temperature of 250° F. and does not again resume its former elastic state; at 600° F. it volatilizes and undergoes decomposition.

Purifying.—In the manufacture of India-rubber the first operation is the purification of the crude material. The impure rubber is cut into minute shreds and is washed by powerful machinery immersed in water, which releases the solid impurities. The washed gum is then placed on iron trays and dried in a room heated by steam. The material then undergoes a process of kneading under very heavy rollers, which causes the adhesion of its various pieces to each other and ultimately yields a mass or block of India-rubber so compact that all air-holes, other cells and interstices disappear.

Chemistry of Caoutchouc.[1]—India-rubber, as is well-known, is the product of the coagulation of the milky juice of a large number of trees, creepers, and shrubs. The commercial article can hardly be expected to be homogeneous, and still less a pure product in the chemical sense. Besides accidental impurities of sand and fragments, it contains a greater or less amount of oily and resinous matter, which varies greatly even in the same brand of rubber. Para rubber contains from 1 to 2 per cent.; Logus rubber from 3 to 7 per cent.; Borneo rubber from 6 to 21 per cent.; and African Flake may contain as high as 64 per cent. Lascelles-Scott gives the composition of a brand of unnamed origin:

[1] The writer uses as his authority for this paragraph and the subsequent ones upon the Chemistry of Vulcanite, "The Chemistry of India-Rubber," by Carl Otto Weber, Ph. D., published by Charles Griffin and Company, Limited, London. J. B. Lippincott Company, Philadelphia, 1903.

India-rubber (gum)	37.13 per cent.
Albumen	2.71 per cent.
Resins	3.44 per cent.
Essential oils	Traces.
Sugar	4.17 per cent.
Mineral matter	0.23 per cent.
Water	52.32 per cent.

The pure Para gum consists of soluble and insoluble portions, the latter averaging about 3.5 per cent. The soluble portion has a formula of $C_{10}H_{16}$ and is the portion with which the sulphur combines to form vulcanite. The formula for the insoluble portion is $C_{30}H_{68}O_{10}$.

VULCANITE.

History.—Charles Goodyear[1] of New Haven, Conn., discovered the process of curing or vulcanizing India-rubber in 1843. Thomas Hancock of England has been credited with making this discovery contemporaneously; but his own writings state that he had seen small samples of Goodyear's work, and that after much experimenting, he produced the same thing; so the priority of the discovery undoubtedly belongs to Goodyear.

On January 30th, 1844, a patent was granted to Charles Goodyear, for making soft or flexible rubber that would resist the action of the usual solvents of caoutchouc, and would not be affected by cold or heat, if the temperature were not raised above the vulcanizing point. The mixture he preferred was: caoutchouc 25 parts, sulphur 5 parts, and white lead 7 parts. This produced soft vulcanite.

The process of making hard rubber was patented by Nelson Goodyear, May 6, 1851. His formula consisted of one-half pound of sulphur to a pound of caoutchouc and one-half pound of any one of a long list of earthy substances.

A patent was granted to Charles Goodyear, Jr. "For improvement in plates for artificial teeth," dated March 4, 1855. He says: "The best compound, I believe to be one pound of India-rubber or gutta-percha (or of the two combined in suitable proportions) with a half pound of sulphur, together with a suitable quantity of coloring matter. To obtain a suitable color, I mix with caoutchouc or gutta-percha, vermilion, oxide of zinc, oxide of iron, of any coloring substance that will stand the necessary degree of heat with the action of sulphur. This compound, after having been molded, is subjected to heat for about six hours, and in so doing, I gradually raise the heat to about 230° F., say in half an hour, and then unless there be a considerable quantity of foreign matter present, the heat may be raised, quickly as may be, to about 295° F.; otherwise, I raise the heat more slowly and keep the compound at about that temperature for the remainder of the six hours and then allow the whole to cool down, when the process will be completed."

[1] This historical sketch of vulcanite is made up largely from the Monograph, "Instructions in Vulcanite" by Prof. E. Wildman, M.D., D.D.S. Philadelphia: Samuel S. White, 1867.

A patent was granted in June, 1857, to H. H. Day for vulcanizing very thick pieces of rubber. To accomplish this, he mixes with the matter prepared for vulcanization, a substance that will prevent its becoming spongy or cellular, by absorbing the sulphur gases as fast as generated. The material which he proposed to employ for this purpose, is ordinary fire clay, but other substances capable of absorbing the gas may be employed.

In Austin G. Day's specification we find some interesting remarks upon the nature of rubber compounds. In contra-distinction to Nelson Goodyear's hard and inflexible substance, he claims his compound to be a hard, but highly elastic material obtained by a process differing from that of N. Goodyear's in the length of time, in the degree of heat, in the proportion of the ingredients, and in the mode of equalizing the temperature. Day's composition is one pound of purified Para rubber and one-half pound of sulphur.

He remarks: "In the vulcanizing process, there is eliminated during the whole operation a constant discharge of sulphuretted hydrogen and other sulphuretted gases, which must have means of escape through the pores of the mass while being vulcanized. By my present improved management of the heat in vulcanizing, by raising it very gradually, step by step, to the highest point, I am enabled to vulcanize pieces of an inch or more in thickness with great uniformity and perfection. A mixture containing earthy matter may be vulcanized in much shorter time than one consisting of caoutchouc and sulphur alone, and yet be solid, owing to the earthy matter facilitating the escape of the gases generated in its substance during the process. At the same time such compositions are destitute of elasticity and flexibility. For a piece five-eights of an inch thick, the time required for vulcanizing is thirteen and a half hours:

It is held at	275° F.,	for 6 hrs.
Then raised to and held at	280° F.,	for 3 hrs.
Then raised to and held at	290° F.,	for 2 hrs.
Then raised to and held at	295° F.,	for 2 hrs.
Then raised to and held at	300° F.,	for ½ hr.

Composition of Vulcanite for Artificial Dentures.—As the formulæ of the various makes of rubber are "trade secrets" of the manufacturers, our knowledge is limited to the general specifications of patent papers and the writings which detail the experiments of Prof. Wildman and others.

Both the soft pliable and the hard flexible vulcanite are used in the construction of dentures. The essential components of vulcanite are caoutchouc and sulphur, the ratio varying according to the use for which the product is designed. All other ingredients are for coloring or to cheapen the product. The soft pliable variety used in dentistry is known as velum rubber, because its most important use is for vela for cleft palates. It contains sulphur to the extent of about one-fifth of the weight of the gum. Hard vulcanite, sometimes called ebonite, contains by weight one-half as much sulphur as caoutchouc.

Some of the formulas given by Prof. Wildman are:

DARK BROWN.

Caoutchouc	48	parts
Sulphur	24	"

GRAYISH WHITE

Caoutchouc	48	parts
Sulphur	24	"
White Oxide Zinc	96	"

RED.

Caoutchouc	48	parts
Sulphur	24	"
Vermilion	36	"

BLACK.

Caoutchouc	48	parts
Sulphur	24	"
Ivory-black or Drop-black	24	"

DARK PINK.

Caoutchouc	48	parts
Sulphur	24	"
White Oxide of Zinc	30	"
Vermilion	10	"

JET BLACK.

Caoutchouc	48	parts
Sulphur	24	"
Ivory-black or Drop-black	48	"

If pure caoutchouc is burned, there should be but about three per cent. of dark ash remaining. Sulphur and vermilion (mercuric sulphide) leave no ash, hence the per centum of ash from rubber containing these materials should be less than three per cent. in the ratio of the amount of these materials to the caoutchouc. Some rubbers leave as high as sixty per cent. of ash. It would be reasonable to suppose that the strength would be reduced in ratio to the amount of the ash, but this is not true, as the pure gum and sulphur produce the strongest vulcanite; the red and black are nearly the same strength, although the black rubber will leave a much larger ash than red, because the coloring matter is animal charcoal composed largely of phosphate and carbonate of lime, while the mercuric sulphide would be entirely volatilized. The oxide of zinc and other earthy matter in the pink and white rubbers have a very deleterious effect upon the flexibility and tenacity of the vulcanized rubber, so much in fact, that these light colored vulcanites are not one-fourth as strong as the brown, red or black.

Physical Properties of Vulcanite.—Vulcanite is hard, flexible, and horn-like in texture. Dr. George B. Snow gives the specific gravity of a specimen of black vulcanite as 1.1974; and that of the same piece before vulcanizing as 1.1333. The specific gravity varies, as it is much affected by the coloring matter, and is also increased by the temperature and time of vulcanization. Caoutchouc expands upon heating. Dr. Snow says: "Rubber expands by heat more rapidly than any other solid body. Its rate of expansion at ordinary temperatures, from 70° to 90° F. is over six times that of iron, about five times that of brass, and nearly four times that of zinc which is the most susceptible to expansion by heat of any of the metals. Its rate of expansion is known to increase as the temperature rises, but it has not been definitely determined." In vulcanizing soon after chemical action begins (248° F.), expansion ceases and contraction commences, the latter being much affected by the contained foreign matter, by a high or low temperature, and by a long or short time of vulcanization. Its increased specific gravity is due to this contraction.

The usual solvents of caoutchouc have but little action upon vulcan-

ite, and no agent which can be tolerated in the mouth has any action upon it. It is susceptible of a high polish. It is very opaque, and, therefore, does not imitate well the appearance of the mucous membrane. It is a very poor conductor of thermal and electrical changes, in consequence of which it is not conducive to the health of the tissues upon which it is worn. It is porous, although this condition is invisible to the eye. It absorbs the secretions of the mouth, even though the rubber has been perfectly vulcanized, and when improperly vulcanized, it becomes so saturated with decomposing secretions that it is exceedingly offensive. Great care should be used in vulcanizing rubber that is to be worn in the mouth, and the patient should be thoroughly instructed in cleansing it.

New rubber can be added to old vulcanite by reheating; hence vulcanite dentures can be easily repaired. It is unnecessary to add a solution of rubber to vulcanite to aid in its repair, as the solvent has no action upon the vulcanite, only leaving a thin layer of soft rubber to penetrate the pores of the vulcanite, a result better accomplished by heat and pressure.

Chemistry of Vulcanization.—Vulcanization consists of the chemical union of caoutchouc and sulphur, probably producing a series of compounds having the formula $C_{10}H_{16}S_2$ for the highest combination, and $C_{100}H_{160}S$ for the lowest, with a series from the lowest to the highest.

Vulcanization can be brought about either by the cold or the hot process, and by using with the latter either the dry or the wet method. The essential requisite is to secure the union of the sulphur with the polyprene ($C_{10}H_{16}$).

The cold process is by the use of sulphur monochloride and is only suitable for very thin layers of rubber, being, therefore not applicable for dental use. An attempt has been made to sell to the profession office rights for the use of a porcelain enamel for facing vulcanite dentures. This method was based upon the cold vulcanization process. While the results were an improvement upon ordinary pink rubber, the product lacked the translucent effect of fused porcelain, its durability was uncertain, and the process was long and tedious.

Mr. Weber in the work previously referred to, says: "We turn our attention first to the question of the general action of sulphur upon India-rubber at high temperatures. The sulphur bath method might appear from several points of view the most suitable method of studying this question, but after a number of attempts, I abandoned it in favor of the method of subjecting carefully prepared homogeneous mixtures of Para rubber with a definite amount of sulphur, to the action of heat. Again in this case we have the choice of several methods of heating, but the one of heating pieces of Para mixture of uniform thickness to vulcanizing temperatures when immersed in water, appeared to me the most satisfactory, as it involves the minimum of loss of sulphur by evaporation.

"The experiments were carried on with strips cut from a calendered sheet 3 mm. in thickness—a mixture of 100 parts of Para rubber with

ten parts of pure precipitated sulphur. These strips were vulcanized in a phosphor-bronze digestor.

"The digestor is provided with a thermometer tube (thermometer in mercury), a pressure gauge, and a blow-off valve. In the digestor a porcelain beaker is suspended so that it is clear of the bottom. The digestor is filled to about one-quarter of its capacity with water; the beaker is completely charged with water, and a number of the strips to be experimented upon, immersed in it. The digestor is then closed, rapidly heated to the required temperature, and maintained thereat, either by carefully adjusting the gas burner, or by means of some form of thermo-regulator. At regular intervals one of the strips is withdrawn after blowing off steam and rapidly opening the digestor, which is then immediately closed again to continue the series. The time error caused by these successive withdrawals does not exceed four minutes per sample. Of course the water lost by the blow-off steam is from time to time made up with boiling water.

"The strips thus withdrawn are marked, and subsequently cut into very fine threads, which are freed from every trace of uncombined sulphur by extraction with acetone in a Soxhlet extractor. The greatest care was employed to render this operation perfect, every sample being subjected to a three days' continuous extraction. The extracted samples were dried in a current of carbonic acid in the water oven, and, until analysis, were preserved in carefully stoppered glass tubes.

"About one gram of each of these samples was used for analysis. The sulphur determinations were all, without exception, carried out by Carius' method, as the results by the much simpler and more expeditious method proposed by Henriques, were found to be liable to an error approaching 0.1 per cent. in magnitude. In this manner the following results were obtained:—

VULCANIZATION OF PARA RUBBER.

Duration of Vulcanization.	Temperature of Vulcanization.				
	120° C.	125° C.	130° C.	135° C.	140° C.
	S.%	S.%	S.%	S.%	S.%
30 mins.	0.71	0.71	0.99	1.76	---
60 "	1.18	1.32	1.44	2.17	---
90 "	1.31	1.67	2.04	2.36	---
120 "	1.62	1.91	2.32	3.92	5.07
150 "	---	---	---	4.02	---
180 "	1.78	2.11	2.94	4.18	6.05
240 "	1.93	2.22	5.00	5.50	---
300 "	2.25	2.35	5.27	6.74	---
360 "	2.60	3.80	5.82	6.88	---
420 "	3.71	4.04	6.04	6.97	---
480	3.94	4.31	6.33	7.13	---

"These figures amply suffice to demonstrate indisputably the fact, even quite recently again denied, that the vulcanization of India-rubber with sulphur involves the chemical combination of these two substances, at any rate as far as the vulcanization of Para rubber is concerned.

"That different brands of India-rubber behave very differently in the vulcanization process, is a well-known fact, but what we know at

this moment respecting the composition and chemical relationship of these different brands entitles us to assume that, although their behavior under vulcanization may not be identical with the Para rubber, it will be more or less closely analogous to it."

Following this, Mr. Weber gives a tabulation of his experiments with Upper Congo, Beni River, Ceara and Borneo rubber for the same duration of vulcanization and for 125° C. and 135° C. He then sums up these experiments thus:

"The extremely interesting results here tabulated remove all doubt that the vulcanization of India-rubber is a chemical process resulting in the formation of a polyprene sulphide. The rate at which the sulphur enters into combination with the India-rubber hydrocarbon (polyprene) is characteristic for each brand of India-rubber. Some of the above series were repeatedly investigated, always with the same result.

"There arises now, of course, at once the question as to the nature of the process by which sulphur enters into combination with the polyprene, whether the polyprene sulphide or sulphides formed are addition or substitution products. Certainly what we already know respecting the chemical nature of India-rubber, leads us to infer that the vulcanization process consists essentially in the formation of an addition product of sulphur and polyprene. This assumption, however, requires support in view of the fact that quite a number of writers, from Payen to most of the recent authors, declare that vulzanization is accompanied by the evolution of hydrogen sulphide, thereby implying that the process is a substitution, and not an addition process. Indeed, most of the recent authors on this subject state this in so many words. We shall therefore have to subject this point to a careful examination.

"Assuming the compound of polyprene and sulphur, which indisputably forms in the vulcanization process, to be a substitution product, it follows with absolute necessity that for each 32 parts of sulphur combining with the polyprene, we must obtain 34 parts of hydrogen sulphide. Now, in the process of vulcanization as practically carried out, we obtain on an average, a product containing, say, 2.5 per cent. of combined sulphur. Consequently the vulcanization of one ton of India-rubber, on the above assumption, would be bound to yield very nearly 60 pounds of hydrogen sulphide, or approximately 18,000 litres. Considering that in a number of factories the amount of India-rubber vulcanized daily largely exceeds one ton in weight, we should expect to find the vulcanizing rooms of these factories reeking with gas. As a matter of fact, however, there is scarcely ever a trace of this gas to be discovered in the rubber works' atmosphere, and the very rare cases in which its presence becomes noticeable may always be considered as an indication of something having gone wrong.

"In the vulcanization of 'hard rubber' goods (ebonite vulcanite) faint but distinct traces of hydrogen sulphide are generally, perhaps always observable, but they could not be ascribed to the vulcanization process proper—the combination of polyprene with sulphur—which process, if it consisted in the substitution of hydrogen for sulphur, should

cause a perfectly torrential evolution of hydrogen sulphide, seeing that 'hard rubber' contains at least 20 per cent. of combined sulphur.

"It is, therefore, certain that if hydrogen sulphide forms at all in the vulcanizing process, its amount is utterly inadequate to support the assumption that the process of vulcanization is a substitution process

"Laboratory experiments on this question lead to exactly the same conclusion. If the experiments are carried out with technically pure Para rubber under conditions absolutely precluding the escape of any gaseous product of the reaction, very minute traces of hydrogen sulphide may sometimes be observed, but in a considerable number of carefully devised experiments with highly purified Para rubber, no hydrogen sulphide at all could be detected.

"If, on the other hand, the 'insoluble' part of India-rubber is mixed with sulphur, and this mixture is subjected to a vulcanizing temperature say, about 135°C.—a considerable evolution of hydrogen sulphide takes place, due to the formation of a substitution product of this insoluble body, $C_{30}H_{68}O_{10}$, with sulphur. This substitution process certainly proceeds much slower than the vulcanization process of India-rubber (polyprene). Under the same conditions of temperature and the time under which polyprene forms a vulcanization product containing 4 per cent. of sulphur, the above named insoluble constituent forms a subtitution product containing at most 0.7 per cent. of sulphur.

"From these facts we are justified in drawing the following conclusions:

"1. The India-rubber hydrocarbon, polyprene $C_{10}H_{16}$, combines with sulphur without evolution of hydrogen sulphide. The vulcanization process of India-rubber is, therefore, an addition process.

"2. The insoluble constituent of India-rubber, which forms only an insignificant proportion of the technical product, not exceeding five per cent. of the total, combines with sulphur under vulcanizing conditions at a very slow rate with evolution of hydrogen sulphide and with the formation of a substitution product.

"The above conclusively settles the question regarding the general chemical aspect of the vulcanization process, but it confronts us with the further question respecting the quantity of sulphur combining with India-rubber in this process, as well as the more intimate structure of the compound thus formed."

Interesting and instructive as the work of Mr. Weber is, the limits of this chapter will not permit us to follow him in detail, but only to give his conclusions.

"The process of vulcanization consists in the formation of a continuous series of addition products of polyprene and sulphur, with probably a polyprene sulphide $C_{100}H_{160}S$, as the lower, and $C_{100}H_{160}S_{20}$ as the upper limit of the series. Physically this series is characterized by the decrease of distensibility, and the increase of rigidity, from the lower to the upper limit. Which term of the above series, that is, which degree of vulcanization is produced, is in every case only a function of temperature, time, and the proportion of sulphur present.

"As a chemical reaction the vulcanization process is not influenced by

the physical state of the India-rubber colloid; but the physical state of the India-rubber colloid, while under vulcanization largely determines the physical constants of the vulcanization product."

From the above we conclude that dental vulcanite is essentially polyprene disulphide having the symbol $C_{10}H_{16}S_2$ which contains 32 per cent. of combined sulphur.

ADVANTAGES AND DISADVANTAGES OF VULCANITE AS A BASE FOR ARTIFICIAL DENTURES.

Advantages.—*First*:—It is easy of manipulation; it can be molded into any form, and it becomes, upon proper vulcanization, very strong tough and flexible. It is repaired with equal ease.

Second:—It is the lightest of all substances used in the mouth; its specific gravity is from 1.15 to 1.50, while aluminum, the lightest metal suitable for use in the mouth, has a specific gravity of from 2.5 to 2.7.

Third:—It is inexpensive, both as to cost of material and labor in construction, thus bringing it within the reach of patients unable to afford metal plates.

Fourth:—There is no material with which contours can be so easily and perfectly restored.

Disadvantages.—*First*:—It is a very poor conductor. It prevents the proper radiation of heat from the mucous membrane over which it is placed, thereby leading to excessive resorption of the hard tissue and lowering the vitality of the soft tissue, in consequence of which they are more subject to the action of irritants.

Second:—Because it is a porous material and because this condition is greatly exaggerated by improper vulcanization, it affords lodgment for bacteria, the products of which are very strong irritants to the soft tissue.

The physical phenomena of expansion and contraction in the vulcanization process are by some considered as disadvantages, but these can be so well controlled by modern methods of manipulation, that they should not be considered.

Red and pink rubber are by many considered injurious because of the coloring matter, vermilion (mercuric sulphide). This criticism is unjust because pure mercuric sulphide is insoluble in water, alcohol, alkali, and all acids, (except nitro-hydrochloric acid), which under no condition should come in contact with red or pink vulcanite, as this acid converts HgS into $HgCl_2$ (corrosive sublimate).

Only high grades of rubber should be used in the mouth as the cheap grades may contain injurious impurities.

CONSTRUCTION OF VULCANITE DENTURES.

The history and the physical and chemical properties of caoutchouc and vulcanite have been treated at considerable length, under the belief that with this information fully set forth, the student will pursue the

study of the technique of the construction of vulcanite dentures more intelligently and with more interest and profit.

It is important in dental technique that every step in the series of an operation be carefully and accurately performed, otherwise the desired results cannot be obtained.

There are two general methods of constructing vulcanite dentures, which we shall name the Double Vulcanization Method and the Single Vulcanization Method. The first method is best adapted to all full cases where contour restoration of the gum tissue is required; also to some partial cases. The second method is best adapted to full cases where little or no gum restoration is required and to the larger portion of partial cases.

FULL UPPER: DOUBLE VULCANIZATION METHOD.

The operation consists of taking the impression, making the cast, forming a base-plate, and finishing the maxillary surface thereof; of obtaining the occlusion models, arranging the teeth and proving the contour and expression; of preparing the case for flasking, packing, vulcanizing, and finishing.

Impressions.—It is imperative in vulcanite work that a perfect plaster impression be obtained. The technique of this operation is described in Chapter VII.

The Cast.—Because of the heavy pressure to which the cast will be subjected in molding the rubber, it should be made of a material that cannot be compressed. The Spence plaster compound is the best for this work. It is better practice in vulcanite work to carve and make additions to the cast for equalizing the pressure of the denture than to alter the impression. The carving can be done as described in the chapter on this subject. Obviously, additions to the cast must be made of a material that will stand the heat of the vulcanizer. Tin is best for this purpose as it does not discolor the rubber. Number 60 tin-foil, which is about .005 of an inch thick, is well adapted for this use, and can be applied in one or more thicknesses by attaching each layer with sandarac varnish. Thicker pieces of tin can be made by rolling out bar tin, after which they are annealed by placing a few moments in boiling water. This tin plate is fastened to the cast by one-eighth inch tacks or brads, or is retained by the tin foil used for finishing the maxillary surface.

The Base-plate.—The cast having been properly prepared, the base-plate is made by warming and evenly forming a sheet of thin base-plate wax over the cast. With a warm wax spatula the excess wax is cut off, permitting the wax pattern to extend one-sixteenth of an inch farther over the sides of the cast than it is desired to have the plate extend when it is finished. The hot spatula is then passed around the edge of the wax which causes it to adhere to the cast. The cast with the wax base-plate is now flasked in a Star or Wilson flask. (Figs. 462 and 463.)

Flasking the Base-plate.—The flasking is done with regular dental

plaster, and should be so arranged that the separation of the two portions will be at the periphery of the wax. The plaster in the first section of the flask must be coated with a separating fluid. Any of the various liquids used for separating plaster, may be used, except oil which should never be used in rubber work, as it has a deleterious effect upon the vulcanizing rubber. After the flask is filled, it should stand until the plaster is thoroughly hard. French's regular dental plaster will require not less than twenty minutes and the slower-setting plasters from thirty to forty-five minutes. The flask is now placed in a stew pan or any convenient receptacle and is covered with cold water. The water is heated to ebullition, when the flask is removed from the water and separated. The wax will be sufficiently softened to permit of easy removal. It is desirable to have all wax removed without melting, but should a portion of the wax be melted upon the cast it should be washed away with boiling water. Some experience will be required to know when to take the flask from the water. Large cases in which the wax is very near the sides of the flask may require opening just before the water reaches the boiling point; while small cases in which the wax is much nearer the centre of the flask may require boiling for a minute or two.

An excess space to receive the superfluous rubber should be cut in the cast portion of the flask, beginning one-eighth of an inch from the mold and extending to the rim of the flask. Small grooves or gateways are cut from the mold to this excess space. (Fig. 446.)

Finishing the Maxillary Surface of the Base-plate.—The surface of the cast should now be coated with a material that will give a hard and smooth finish to the maxillary surface of the vulcanite. There are two general methods, which are known as the tin, and the liquid-silex methods.

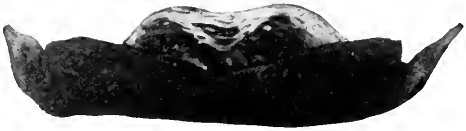
The Tin Method.—This method is preferable as it gives a smoother and denser surface to the vulcanite, especially if any wax has been melted into the cast. A sheet of No. 6 or No. 10 tin-foil is nicely fitted over the cast with the thumb and finger. It is then removed and the excess of tin cut away with sharp scissors, as indicated by the imprint of the edge of the cast upon the tin. The cast is now coated with sandarac varnish, and the tin is at once replaced, and firmly pressed and gently rubbed with a wad of soft tissue paper until there is perfect adaptation to the cast. The tin should be rubbed until it has a well burnished surface. It is important that the tinned cast be coated with a lather of soap. This is accomplished by wetting a soft bristle brush and rubbing it upon a cake of soap and then upon the palm of the hand, until a smooth lather is formed, which is applied to the tinned surface; or a thin wash of Johnson's ethereal soap may be used. If the soap is not applied, the tin and vulcanite will adhere very strongly and can only be separated by dissolving the tin with mercury or hydrochloric acid.

The Silex Method.—The liquid-silex method has the advantage of being more easily applied, and if the surface of the cast is entirely free of wax or oily substances, it will give nearly as good results. A clean ox-hair or camel's-hair brush is dipped into the liquid-silex and is then ap-

plied to the cast. It will be necessary to occasionally dip the brush into water, so that the silex may be well diluted and evenly applied. The excess of silex should be absorbed with a cloth. Another method is as follows: while the thin silex is still moist upon the cast, dust with talcum powder and when dry, rub carefully with a soft cloth. The liquid-silex bottle should be kept well corked and no particles of plaster be permitted to get into it, as they will precipitate and spoil the silex for use. The brush must be well washed each time it is used.

Packing the Base-plate.—The cast having been coated either with the tin or with the liquid-silex, the counter portion of the flask is placed plaster side down, upon a piece of sheet iron over the gas stove. The cast portion of the flask is placed upon the sheet iron with the cast

FIG. 436



The base-plate.

downward, and one edge resting upon the other section of the flask so that the cast does not touch the sheet iron; heat is applied for three or four minutes or until the plaster is as hot as the fingers can bear when pressed upon it. The case is then removed from the sheet iron and a piece of brown or black rubber large enough to cover the cast is placed in the mold in the flask. If there is any doubt of the rubber filling the mold, an extra piece should be added. The two portions of the flask are placed together and gently pressed in the flask press until closed. (See Figs. 468 to 470.)

Vulcanization of the Base-plate.—The flask is then clamped or bolted and placed in the vulcanizer (see Figs. 472 to 481), and sufficient heat is applied to raise the temperature to 320° F. and sustained for fifty minutes. When the flask is cold the case is removed and all plaster cut and brushed away.

Finishing the Base-plate.—The periphery of the base-plate is trimmed with a vulcanite file to the desired outline, and the labial, buccal, and lingual surfaces are scraped, so as to have a clean, fresh-cut surface for the attachment of the teeth and contouring rubber.

Obtaining the Occlusion Models.—The base-plate, Fig. 436, is placed in the mouth and the patient is instructed to swallow; when, if the conditions are favorable, it will be firmly retained. With the index finger, pressure should be exerted upon every portion of the base-plate to see if this tends to dislodge it; and if so, the cause should be noted to see if the fault can be corrected. It is to be observed if the labial and buccal fræna are sufficiently relieved, that the plate at the canine eminence is as high as can be worn, and that the distal edge of the plate does not extend too far backward. If there are faults that cannot be corrected a new impression should be taken and the work started again. In some cases the soft tissues are so very tense that adhesion will not take

place at once. In such cases the index-finger of the left hand should be placed against the vault of the base-plate and the test made as before,—when, if the base-plate sets firmly at every point and the peripheral line is correct, the operator may be assured the finished denture will adhere after it has been in the mouth a short time.

A satisfactory base-plate having been obtained, wax should be formed over the alveolar ridge of the base-plate to restore the contour of the gum and the outline of the teeth, by repeatedly trying in the mouth and adding to or taking away the wax until the desired effect is produced. (Fig. 437.) The objects sought are: (1) that the lips and cheeks be

Fig. 437

The base-plate with wax added used for the bite-plate.

held in as near the normal condition as possible; (2) that the wax be built the full length of the lip, thus indicating the incisal line of the teeth; (3) that the occlusal edge of the wax be carved to receive a slight imprint of the cusps and incisive edges of all the lower teeth, and (4) that a line be drawn in the wax to indicate the median line of the face and also the high lip line at the highest point at which the patient can elevate the lip by muscular action.

Sufficiently well-softened pure beeswax should be placed in a lower tray and a perfect impression of the occlusal and incisive surface and at least half the length of the lower teeth be taken. This impression may be filled with regular dental plaster or better, Spence compound, because of its great hardness.

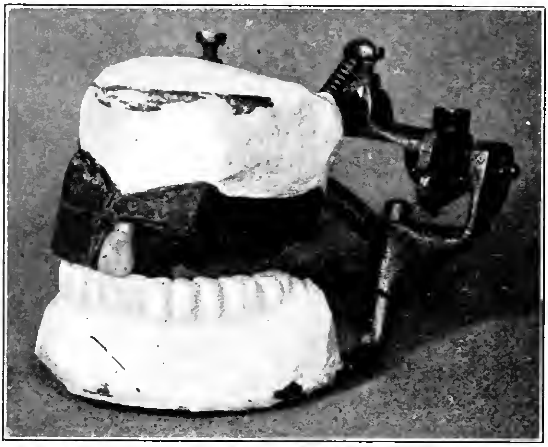
Teeth of suitable size, form and color (see Chapter XII.), should now be selected and the patient dismissed.

The base-plate with its wax occlusion model and cast of the lower teeth should be adjusted upon an anatomical articulator. (Fig. 438.) If there are heavy undercuts in the base-plate, they should be filled in with soft wax, but if the undercuts are not sufficient to interfere with its easy removal from the supporting cast, no wax will be needed. The cast of the lower teeth should be adjusted to the imprints of the teeth in the occlusal edge of the wax model and sufficient regular dental plaster mixed to fill the base-plate and attach all to the articulator. Attention should be given to placing the case squarely upon the articulator, the occlusal surface of the teeth parallel with the lower bow, and

the median line at the incisive edge of the teeth four inches from the condyles. The Snow face-bow in connection with the Snow articulator furnished a good means for accurately adjusting the case. Fig. 439 shows wax model removed.

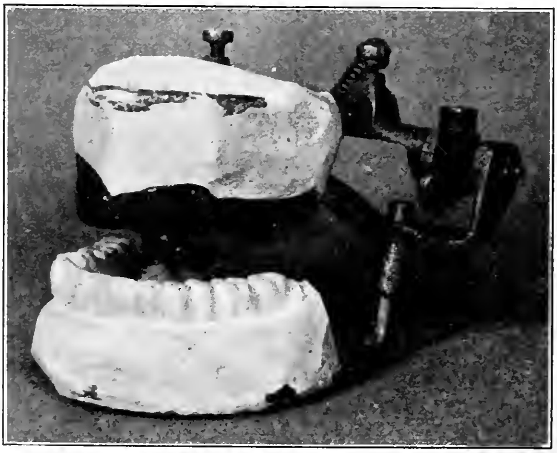
Arranging the Teeth. A section of the wax model extending from the median line and the high lip line backward to the first molar, upon

Fig. 438



Casts mounted upon articulator: wax removed for setting up of teeth on one side.

Fig. 439



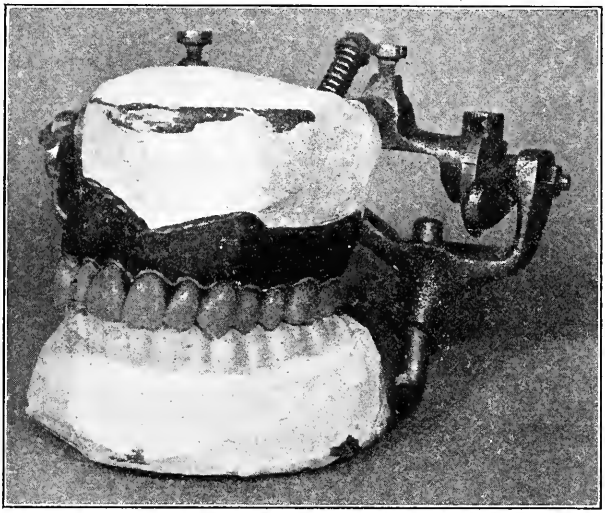
Base-plate on articulator with wax removed.

one side only, should be removed. (Fig. 438.) Arrange the teeth in this space so as to restore the contour of the removed wax, and at the same time follow the instructions in Chapter XII. Wax should be melted about the lingual and cervical portion of the teeth to securely fasten them. The remaining segment of wax representing the molars should now be removed and the teeth secured in their position. The

opposite side is treated in like manner. The contour of the gum is restored by aid of a wax spatula and the addition of wax where needed. The wax can be nicely smoothed by passing it through the Bunsen flame. The teeth may be cleaned of wax by using a cloth wet with chloroform. The case should now be taken from the articulator. If any wax has been placed upon the maxillary surface it must be removed.

Proving the Antagonization, Contour, and Expression.—The case should be placed under the faucet to chill the wax and moisten the maxillary surface; it is then placed in the mouth. The occlusion must first be considered. Examine the molars and bicuspids with a mouth mirror and use a thin spatula blade to determine if there is equal pressure upon both sides. The antagonization can be inspected by requesting the patient to carefully close the teeth in various positions. The in-

FIG. 440



Teeth set up and strings in place.

cisors are studied by taking a position in front of the patient, and requesting the patient to raise the upper lip, thus observing the location of the median line and the inclination of each of the six anterior teeth. (See Fig. 457.) The contour is proven by studying the face. Standing at the side of the patient observe the profile and see that the upper lip is in harmonious relation to the lower, also that the lip has its normal fulness throughout its length. (See Figs. 455 and 456.) The operator should again take a position in front of the patient. Attention should be given to the incisive fossæ and canine eminences, and especial attention be given to the triangles formed by the wings of the nose and cheeks, which are influenced by the apices of the canines. If it is desirable, the cheeks can be contoured to a limited extent by the addition of wax contours (plumpers) over the molars. Having obtained the desired results in a state of rest, the operator should engage the patient in conversation and observe the effect. The case is now cleansed of the secre-

tions of the mouth by holding under the faucet and drying with a cloth. If any of the teeth are loose, they must be securely fastened, and the wax smoothed without changing its form.

The double vulcanization method is especially adapted for restoring the contour and expression, because this work is done in wax, when the wax form can be easily and perfectly reproduced in vulcanite.

Preparing the Case for Flasking.—Strings are used for outlining the festoons and periphery of the gum. The object of the festooning string at the cervical portion of the teeth is to give the proper thickness to the margin of the gum. The string used for this purpose is waxed dental floss, twisted very hard, doubled, and twisted again. In doubling, the loop will show the direction in which it should be twisted the second time. Wax the string well with softened wax and apply it by grasping the left heel of the plate between the fingers and thumb of the left hand, with the occlusal surfaces of the teeth upward; place one end of the string at the distal surface of the second molar, pressing it gently into the wax; outline the margin of the gum, using the wax spatula to carry the string well into the interproximal spaces. The peripheral string should be well-waxed wrapping twine, placed at the outer edge of the wax, and secured in place by melted wax made smooth with a hot spatula. (See Figs. 440, 449, and 459.)

The next step is to cover the buccal and labial surfaces with a strip of No. 60 tin foil. Instructions are necessary in applying the tin over the strings. The No. 3 instrument of the Evans set of carvers (Fig. 460), is especially adapted for adjusting the tin foil. The strip of foil is placed over the wax and teeth and pressed as closely as possible into position with the fingers. Hold the work in the left hand, seize the ivory-pointed instrument by the hand grasp, rest the thumb upon the occlusal surface of the second molar and burnish the tin closely to the tooth and against the festoon string. Continue this operation with all the teeth. With a sharp chisel cut away the excess of tin upon the teeth to within one-sixteenth of an inch of the festoon string. (See Fig. 441.) After readjusting the tin about the teeth, the metal must be burnished over the string to give the desired thickness of the gum and the contour of the festoon. This is done by holding the plate and burnisher in the same manner as before. The instrument must extend one-sixteenth of an inch behind the string and at the same time must rest upon the body of the tooth while pressing the tin down over the festoon string. By this means a proper thickness and contour is given the margin of the gum, without forming an unnatural beaded edge. After all the teeth have been thus treated, the position of the plate should be reversed in the left hand, so that the thumb of the right hand may rest upon the periphery of the plate while burnishing the tin from the festoons towards the edge of the plate. With a pair of sharp curved scissors trim the tin flush with the peripheral string, but do not permit it to overlap the vulcanite base-plate. (See Fig. 441.) The case is now ready for tinning the lingual surface. Use No. 60 foil and if the vault is a high one, slit the tin from the middle of one side to the centre. Place the inner end of the slit over the middle of the vault, and one edge

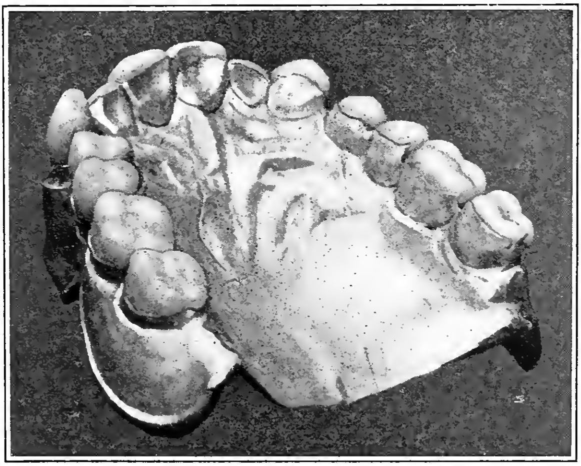
of the slit along the median ridge to the incisor teeth; press the side of the foil gently against the wax and teeth; press the other half of the tin in the same manner into position, permitting the slit portion to overlap the first half. With sharp scissors trim the tin nearly down to the

FIG. 441

Tin-foil applied to labial and buccal portions of denture.

teeth. Remove the foil and place it upon a plaster or metal cast[1] having well-defined rugæ and burnish the rugæ into the foil. Remove the foil, turn it over and fill the impressions of the rugæ with wax, also smear the remainder of this surface with a thin layer of wax; now re-

FIG. 442



Tin-foil applied to lingual surface. Showing rugae and carving of the lingual surfaces of the teeth.

place the waxed surface against the vault of the plate and nicely adjust with the fingers. The tin must be securely burnished against the teeth. The lingual contour of the teeth[2] is reproduced by burnishing their forms in the tin. (See Fig. 442.)

[1] A suggestion of Dr. A. DeWitt Gritman of the University of Pennsylvania.

[2] In the International Dental Journal for August, 1905, Dr. William M. Fine describes and beautifully illustrates his method of carviug the lingual contour of the teeth.

Flasking.—A flask with a narrow rim is imperative. The Star flask will do very well, but one made by the Cleveland Dental Manufacturing Company, called the Wilson flask, will better serve the purpose.

FIG. 443

Cast and denture invested in Wilson-flask.

This flask is designed to be used with the Donham clamp. (See Figs. 463 and 464.)

The maxillary surface of the case, having been cleansed of wax, is filled with Spence's compound, which forms a cast upon which the denture is vulcanized. This vulcanization cast should be not less than

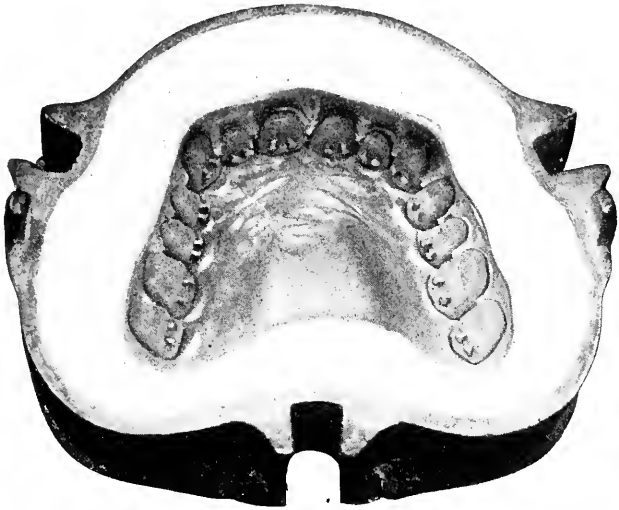
FIG. 441

Counter portion of Wilson flask.

one-fourth of an inch thick at the thinnest portion of the vault, and should not overlap the tin facing. In one hour this cast will be sufficiently hard to place in the first section of the flask with regular dental plaster. (See Fig. 443.) The peripheral string will be a great aid

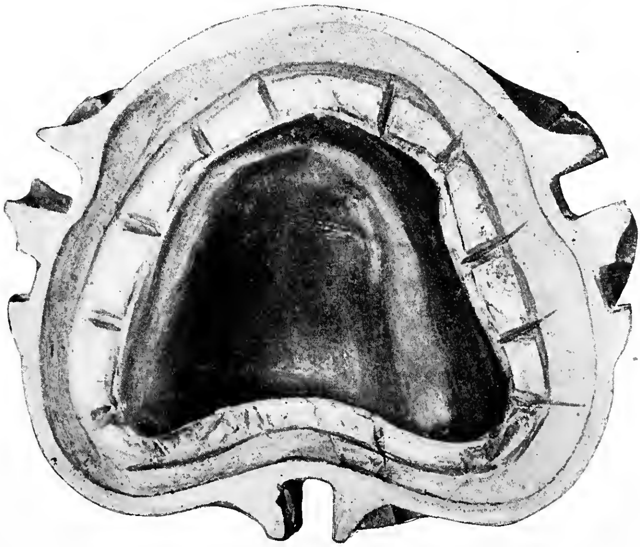
in outlining the denture in the investment plaster. After the plaster has set it is coated with a separating fluid, and then held under the faucet so as to moisten the tin foil and thus facilitate the flowing of plaster into the interproximal spaces at the time the flasking is com-

Fig. 445



Invested case: flask opened and wax removed ready for packing.

Fig. 446



Lower portion of flask, showing invested base-plate and outlet vents for the excess of vulcanite.

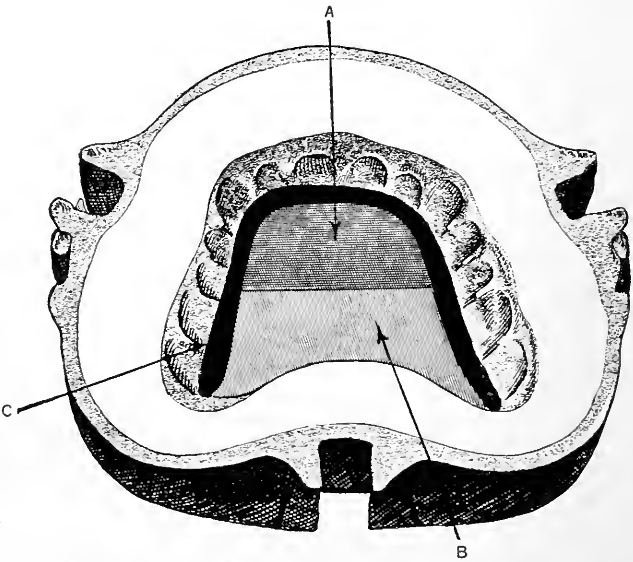
pleted. The flask should stand about twenty-five minutes and then be placed over the stove in a stew-pan of cold water to be heated up as before described.

Separating the Flask.—When the heat of the water indicates the

time of opening, the flask is grasped with a cloth holder in the left hand and separated by the point of a knife blade or wax spatula inserted at the heel of the flask. The instrument should be guarded by the thumb and finger of the right hand to avoid the possibility of marring the case. The strings and as much of the wax as possible are removed with the spatula, when the remainder is removed by pouring boiling water upon it; then with a cloth the vulcanite base-plate and tin lining are wiped dry. (Figs. 445 and 446.) The excess space is cut with small gates (see Fig. 446), and the separated flask is placed over the sheet iron to warm as previously described.

Packing.—Sufficient Gilbert Walker's granular gum or pink rubber is cut into strips to form a layer of one thickness over the tinned surface. First pack a narrow strip of red rubber about the pins (Fig. 447, C), and small square or triangular pieces of granular gum between the cervical portions of the teeth. The strips of granular gum are then placed over the labial and buccal surfaces of the matrix with the fingers and wax spatula so that no space remains through which the red rubber can escape. The strip of red rubber about the pins

Fig. 447



Invested case partially packed. A, half circle of granular gum; B, thin granular gum; C, strip of red rubber about the pins.

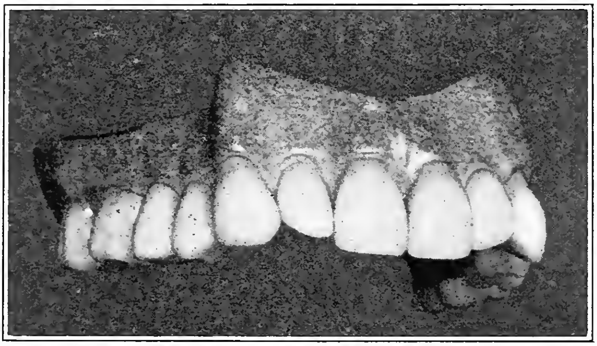
should be pressed down with a wax spatula to form a symmetrical outline. A piece forming half a circle of granular gum is then placed over the anterior portion of the lingual surface (Fig. 447, A), and with the wax spatula the circular edge is joined to the red rubber about the pins of the teeth. A piece sufficiently large when stretched to half its thickness (Fig. 447, B), is then applied over the remaining portion of the lingual surface, and its edges are united to the contiguous rubber. Strips of red rubber are then placed over the teeth to nearly but not quite

fill the mold. A separating cloth of closely woven cotton, or the cloth removed from the rubber after the sizing has been washed out, is saturated with water and placed over the rubber in the mold—when the two sections of the flask are placed together. If the packing has been expeditiously done and the rubber is sufficiently warm, it is placed in the flask press and gentle pressure applied. The flowing of the rubber should be followed every ten seconds with a partial turning of the screw until the flask is closed. The flask is then removed from the press and separated. If there is not an excess of rubber, the cloth will easily separate from the rubber, but should there be strong adhesion, saturation of the cloth with water will facilitate its removal. If the plaster has become nearly cold while packing, the flask should be placed in boiling water for five minutes before it is pressed.

Vulcanizing.—The case is vulcanized in the same manner as the base-plate. Preference is given to low temperature and long time, 300° F. for three hours from the time of applying the heat. It should not be taken from the flask until it is cold.

Finishing.—After washing to remove the loose plaster, the tin can be easily stripped off, and the excess vulcanite filed from the periphery of the denture. A sharp chisel should be used to trim about the labial and buccal surfaces of the teeth, but the lingual surface should be trimmed with a scraper. The file marks about the periphery of the plate should

Fig. 448



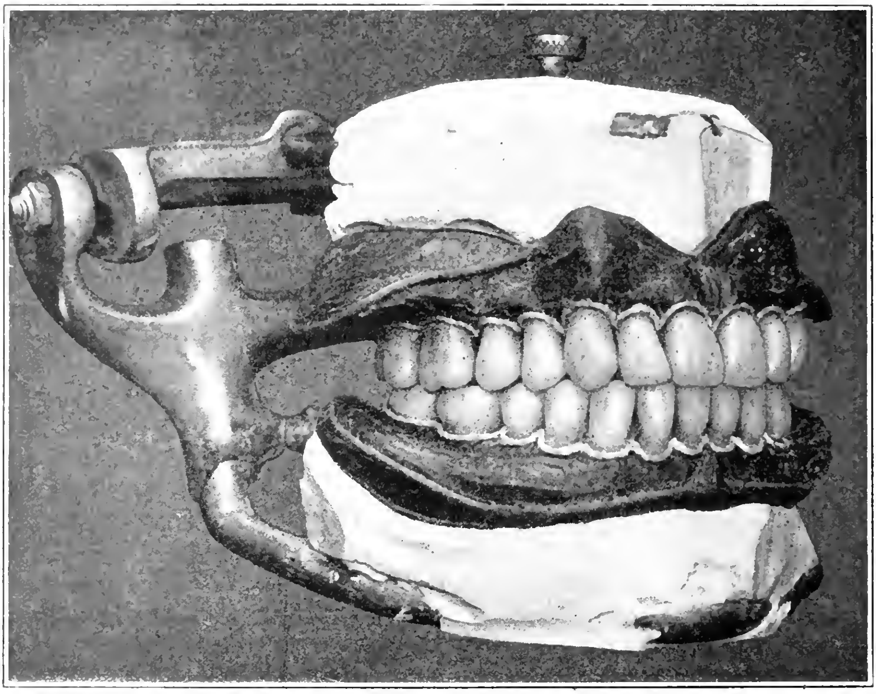
Completed denture for case A.

be removed with fine sandpaper. The labial, buccal and lingual surfaces are buffed with felt wheels and cones carrying pulverized pumice and water. The spaces between the teeth are best reached with a stiff bristle brush wheel, using wet pumice. All the surfaces including the maxillary, are glossed by using a rapidly revolving soft brush wheel and whiting wet with alcohol or water.

Case A.—Figs. 438, 439, 440, 441, 442, 448. Constructed for a lady about fifty-five years of age, and of the bilious temperament modified by the nervous. Teeth, S. S. W. natural forms, mold number 227, shade number 47. The illustration will show that nearly all the teeth were ground for the purpose of occlusion or to represent age. and the laterals to represent a personal peculiarity. When the finished

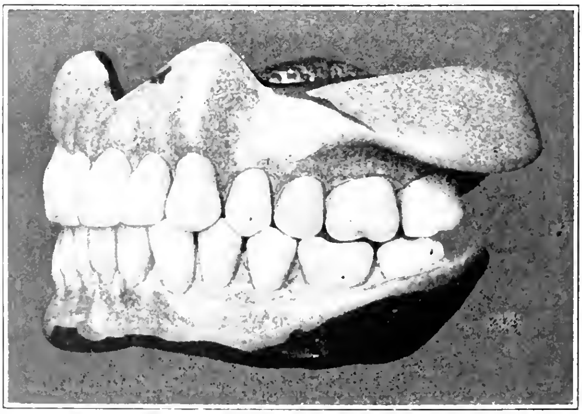
denture was placed in the mouth it was observed that the centrals and canines were too much curved in the long axis of the teeth. The labial surface of these teeth was ground to give them the square angular

Fig. 449



Full upper and lower cases waxed up, showing large contours and method of using waxed string.

Fig. 450

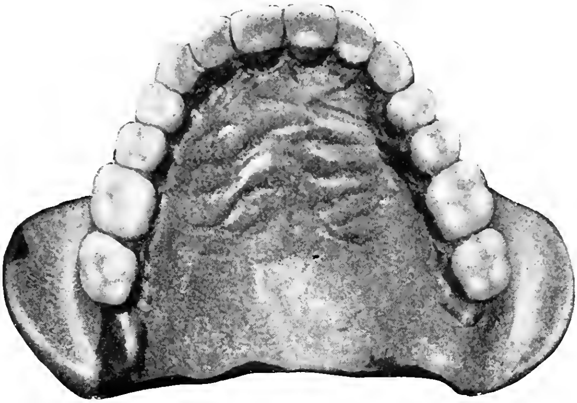


Completed dentures for case B. Note large contours on buccal surface of upper plate.

form indicative of the bilious temperament, thus completing the harmony in form. These ground surfaces were then given a dull polish as described in the paragraph "Grinding and Polishing" under the

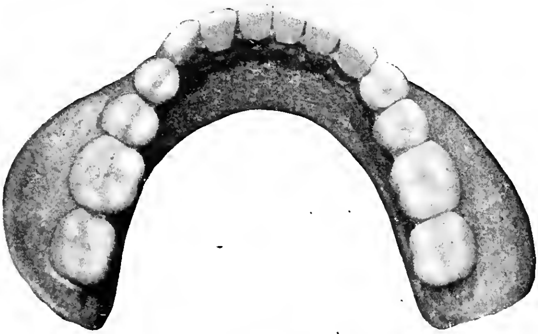
heading—"General Technique Instruction." These photographs were made before the grinding of the labial surfaces. Attention is called to the canine eminences and the incisive and canine fossæ.

Fig. 451



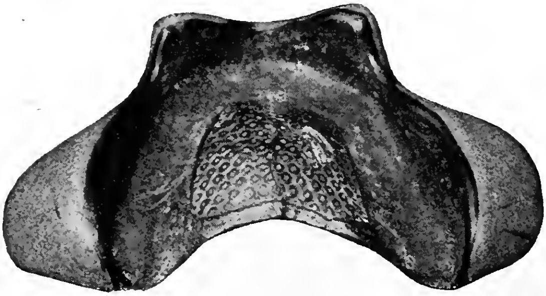
Lingual surface of upper plate shown in Fig. 450.

Fig. 452



Occlusal surface of lower plate shown in Fig. 450.

Fig. 453



Maxillary surface of plate shown in Fig. 450.

Case B.—Patient about forty-five years of age, of a strong sanguine temperament, with a nervous temperament modification. The patient had worn artificial dentures for fifteen years. Teeth used, S. S. W.

natural forms, mold number 202, shade number 40. Attention is called to the extensive contours; also the general rounded outline indicative of a sanguine temperament. (Figs. 449 to 457 inclusive.)

Case C.—Lady thirty to thirty-five years of age. Marked nervous temperament with sanguine temperament modification. Teeth S. S. W. natural forms, mold number 215, shade number 31. (Fig. 458.)

Fig. 454

Mandibular surface of plate as shown in Fig. 450.

Fig. 455

Profile view of patient described as case B. Before the insertion of the denture.

Fig. 456

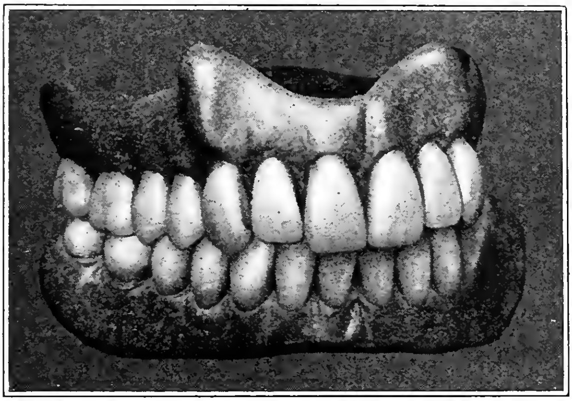
Profile view of patient with denture in place.

Case D.—Lady about fifty years of age. Sanguo-lymphatic temperament. Teeth, S. S. W. natural forms, mold number 223, shade number 40. Gum restoration about the thickness of a sheet of base-plate wax. Only suitable for construction by single vulcanization method. (Fig. 459.)

FIG. 457

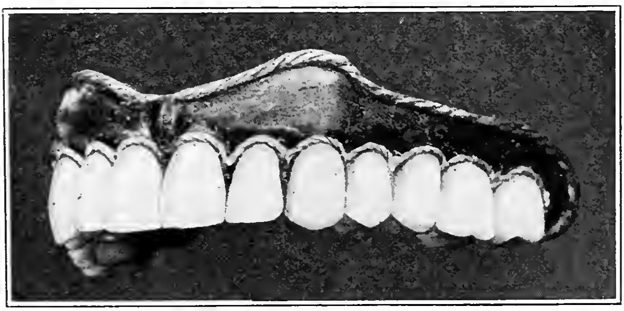
Three-quarter view of patient with denture in place.

FIG. 458



Completed denture for case C.

FIG. 459



Denture for case D.

FULL UPPER: SINGLE VULCANIZATION METHOD.

A Spence compound cast is made from a plaster impression, upon which is formed a base-plate of pink paraffin and wax, modelling compound, or any of the hard gum base-plate materials upon the market. The wax is arranged in the same manner as upon the vulcanite base-plate for obtaining the occlusion models. (Chapter X.)

The cast and occlusion models are attached to the articulator. The teeth are arranged, the gum contoured, and the case tried in the mouth. It is obvious that it will be more difficult to prove the occlusion, contour and expression, because of the imperfectly fitting trial plate. (Fig. 440.) The denture is then cleansed of the secretions of the mouth, dried, and the tin foil adjusted upon the wax. With a hot spatula and a little wax the case is sealed to the cast. The cast is then well saturated with water, when it can be easily removed from the articulator by inserting the end of a knife blade between the cast and attaching plaster. It is then ready for flasking, as in the previous case.

The labial and buccal surfaces are packed with granular gum or pink rubber as in the other method, but the lingual surface is packed entirely with red rubber. Care should be exercised to properly distribute the rubber about the mold and to use no excess for the first closing of the flask. After removing the separating cloth, sufficient rubber is added to fill the deficiencies and give a slight excess when the flask is closed. It is then vulcanized and finished as in the former case.

FULL UPPER: SINGLE VULCANIZATION SUB-METHOD.

The procedure is the same as the preceding method, up to the preparing of the case for flasking. The strings and tin foil are not applied, but the wax form is nicely smoothed in the Bunsen flame or by use of soft cloth or cotton and some solvent of wax,—chloroform is the least objectionable. The case is then flasked and the rubber packed against all portions of the plaster, except the cast, which should always be finished either with the thin tin and soap, or silex. Owing to the rough surface produced by contact with the plaster, it will be necessary to file, scrape and sandpaper the entire labial, buccal and lingual surfaces before they are ready for polishing, thus more than offsetting the time saved by not applying the strings and heavy foil. The surface produced is not as hard and dense as that obtained from contact with the metal.

FULL LOWER: DOUBLE VULCANIZATION METHOD.

The only difference in method of constructing the lower and upper dentures is in the application of the peripheral string, which in the lower should completely encircle the base-plate; while in the upper the distal edge is not outlined from heel to heel.

FULL LOWER: SINGLE VULCANIZATION METHOD.

The one detail in the construction of this lower denture, which differs from that of the upper one, is the necessity for adding a 16-gauge soft iron wire stiffener over the wax base-plate, to give rigidity in securing the wax occlusion models, and later while proving the occlusion by trying in the mouth. The wire is removed from the flask with the wax. See Chapter X. for other methods of taking the bite.

PARTIAL CASES.

These are usually made by the single vulcanization or sub-method. They differ from a full case in the manner of flasking and packing, which will be explained under the heading "Flasking."

GENERAL TECHNIQUE INSTRUCTIONS.

Flasking.—*Rule I.*—All full cases and partials with gum restorations should be flasked so as to separate at the periphery of the wax. The Wilson or Star flask is best adapted to this class of work. If the Star flask is used, the case must first be imbedded in the narrow rim portion of the flask.

Rule II.—All partial dentures without gum restorations, and most repairs must be so imbedded in the first section of the flask, that the teeth are held securely in apposition with the cast, when the flask is opened. The Star flask, using the wide rim first, or any of the various forms of flasks of the Whitney type, are best for these cases. Under this rule the cast and denture are imbedded in the encasing plaster of the first section of the flask, the wax only being exposed. The plaster in the first section must be so shaped that the two portions of the flask can be easily separated.

In connection with this rule, attention is called to a class of repair cases that perplex the novice; namely, those having an extensive fracture upon both the lingual and buccal or labial surfaces. This difficulty in flasking is overcome by attaching one or more shafts of wax, one-fourth inch in diameter, at suitable locations over the fracture upon the labial or buccal surface. The shaft of wax must be sufficiently long to extend through the encasing plaster. When the plaster has hardened, a portion of the wax shaft and the surrounding plaster is cut away to form a cone-shaped depression, which will be filled in with the plaster in the top section of the flask. These wax shafts will form openings through which the rubber can be packed, and which are to be filled with rubber. After vulcanization the shaft of rubber may be removed with a mechanical saw. (See Figs. 515 and 516.)

The salts NaCl and K_2SO_4 should never be used to hasten the setting of the plaster in the flask, as they weaken it and make the warping of the plate during the closure of the flask more liable.

Packing.—When the case is prepared for packing as described in the double vulcanization process, some operators prefer placing the cold

rubber in the flask, because it is firmer and easier to handle, and will soon become warm and pliable from the heat of the flask; other operators prefer warming the rubber as well as the flask, and it is better for all students to do so until they have gained dexterity and confidence in their ability to quickly pack the case before the flask becomes too cold.

A convenient way to warm the rubber is to heat in hot water a piece of soap-stone (a small-sized foot warmer), and after the rubber is cut into suitable strips, it is placed upon the stone. By this means the stone does not become too hot, and holds the heat well. Another device is a porcelain dish upon which the rubber is placed and is kept warm by placing the dish upon a receptacle containing hot water. A specially constructed warming-oven as described by Drs. Essig and Evans in the former editions of this book, serves an excellent purpose. (See Fig. 471.) It is very essential in packing a case that the rubber shall be evenly distributed through the mold so that in closing the flask there will be no undue pressure at any point, thus avoiding a warped denture or elongated teeth.

Vulcanizing.—For convenience, cleanliness and uniformity of results, dental vulcanization is accomplished in a specially constructed machine, called a vulcanizer (see Figs. 472–481). which is a steam-tight boiler. The operation can be accomplished in a sand, glycerine or oil bath, but this is not desirable for obvious reasons. The time of vulcanizing will be influenced by both temperature and the surrounding medium. Vulcanization begins at 248° F., but at that temperature it would require many hours; at 280° F., it will require 5½ hours; at 300° F., 2½ hours; and at 320° F., fifty minutes. The medium surrounding the flask in the vulcanizer must be either water, steam or air. The time required to produce the same result will be in inverse ratio to the conducting power of the medium; water being the best conductor of heat will require the least time, steam second, and air being the poorest conductor, will require the longest time.[1] It is always best to permit the vulcanizer to stand until it is cold before opening, but when it is necessary to expedite matters, the steam may be blown off, the vulcanizer opened, and the flask be set in a pan of cold water. This last procedure would be condemned by some, but owing to the poor conducting and radiating property of plaster, it is doubtful if this method of cooling ever accounts for fractured teeth. Under no condition however should the flask be opened until the plaster in the centre of the flask is cooled to blood heat, which will be sometime after the flask is cold if placed in water.

Finishing.—The filing is done with a rather coarse file especially made for this work. See Fig. 483. A seven or eight inch half-round file having an oval and a flat side, a coarse and a fine end, is a very desirable instrument. The cutting is done with a push stroke. A

[1] The writer's custom is to have the flask submerged in water and use sufficient heat to reach the required vulcanizing point, (300° F.), in about thirty minutes, and to maintain that temperature for two and one-half hours; but when time is an object, to take thirty minutes to attain the 320° F., and maintain that temperature for fifty minutes.

round or rat-tail file is also very useful. For scraping and trimming the plate, short shank Kingsley scrapers numbers 1 and 5, and an Ivory scraper number 9, and a Wilson or a Spaulding chisel, make a very complete equipment. See Figs. 484–487. These instruments should be kept very sharp by grinding and honing. The sandpapering is done with a two inch square piece of number ½ or 1, followed with number 00 paper. The paper is cut into squares by placing the sand side down over a crevice and cutting with a knife. Various substances are used for buffing wheels and cones, but felt has proven the most satisfactory. The wheels have either a square or a knife-edge. The knife-edge soon becomes so blunt that it fails to do the work for which it was designed. This difficulty can be overcome by using a worn-out half-round file ground to a sharp edge, held by an end grasped in each hand, when the felt wheel can be quickly and safely turned to shape. The felt carries the abradant, of which pumice is the best, and must be kept well moistened; otherwise the vulcanite will be heated and possibly warped. The wheel should be run at a moderate speed, and the hands holding the work firmly against the felt carrier must be kept in constant motion, so that symmetrically curved surfaces may be formed, and not ridges and grooves, as the result of too long continued contact at any one place. A large and small size of each of the forms of the buffers used should be provided. A stiff converging bristle brush-wheel, in which the bristles have been worn or cut away one-half, will be more effective for buffing between the teeth. Striking the work against the moderately revolving brush will cause the bristles to reach the innermost spaces. As before stated, the glossing is done by using a rapidly revolving soft bristle brush-wheel and whiting wet with alcohol or water. Very good results can be obtained by rubbing the surface of the vulcanite in the hand with dry plaster of Paris.

Grinding and Polishing the Teeth.—It will often be necessary to grind the exposed surfaces of the teeth, which should again be polished. The abraded surface should be well sandpapered. The paper is held against the ball of the thumb which will conform the paper to the surface of the teeth and greatly facilitate the removal of the facets formed by the grind-stone. It is then buffed with the felt wheel and pumice; or a specially prepared rubber wheel can be obtained for this work.

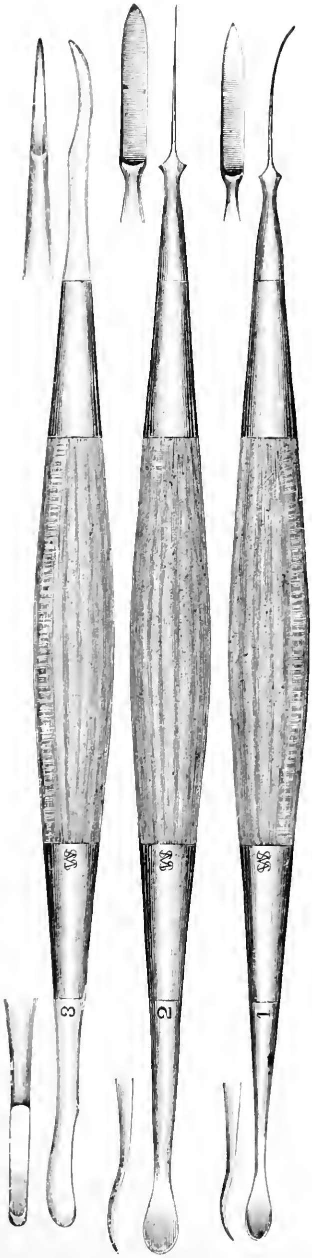
Notching the Cervical End of the Teeth.—In some cases where there is gum restoration, it is desirable not to have the rubber overlap the cervical end of a tooth, and in these cases cruciform notches should be cut in the cervical end with a small knife-edged stone, into which the rubber will flow and harden and aid in supporting the tooth.

INSTRUMENTS AND APPLIANCES USED IN VULCANITE WORK.

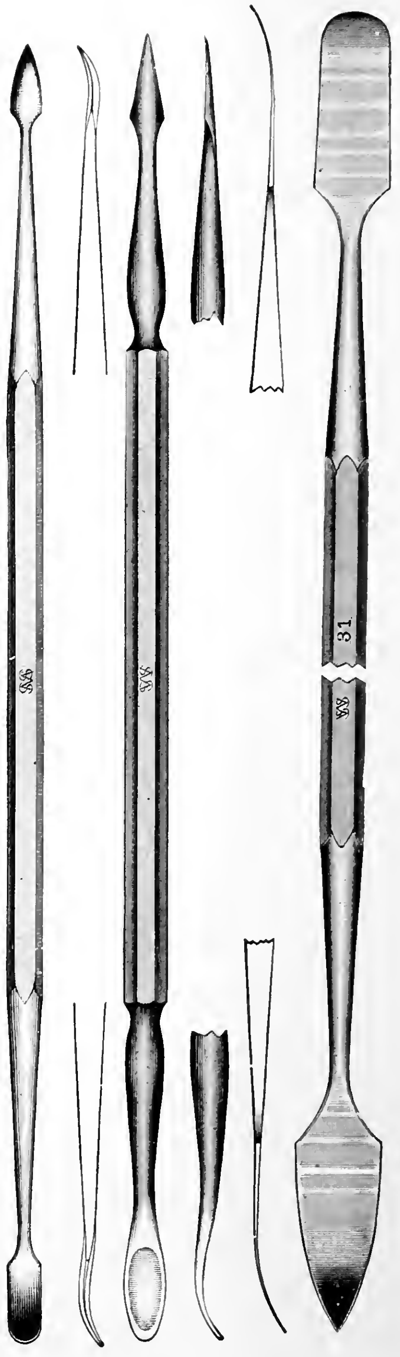
Wax Spatulas.—The instruments shown in Figs. 460 and 461, are some very useful forms. The Evans' numbers 2 and 3 and one of the others, will meet every requirement.

Fig. 461

Fig. 460



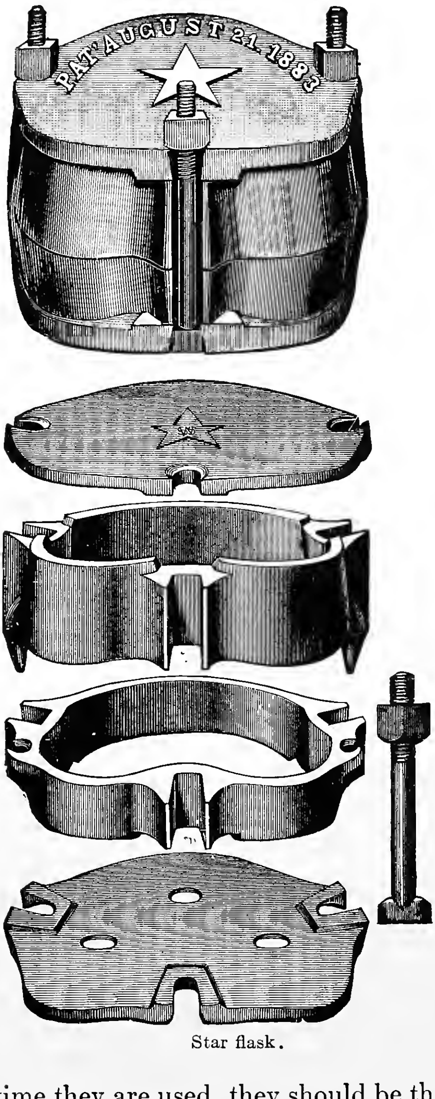
Evans' carving tools.



Wax spatulas: Dorance, Burchard, Gritman.

Flasks.—There are a great many varieties of vulcanite flasks upon the market. They are made of iron and brass. Iron has the greater affinity for oxygen and sulphur in vulcanizing and so is not as desirable as brass for this purpose. The brass flasks are the more easily

Fig. 462



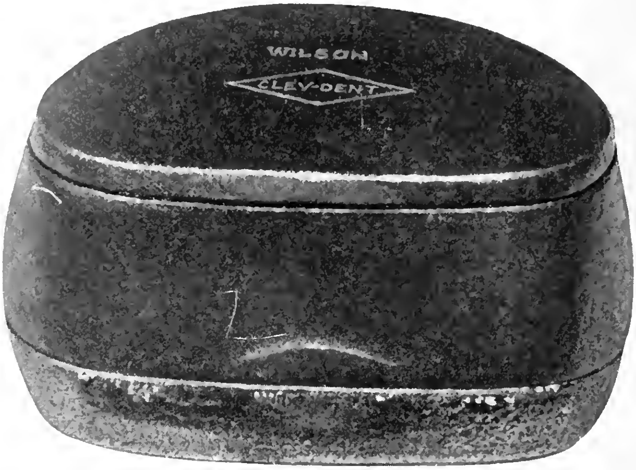
Star flask.

cleaned. Each time they are used, they should be thoroughly cleaned with a stiff brush and sapolio.

The Star flask is one of the oldest forms, and being reversible, is probably adapted to more cases than any other. (Fig. 462.) The Wilson flask is characterized by a very narrow rim upon the lower section, with

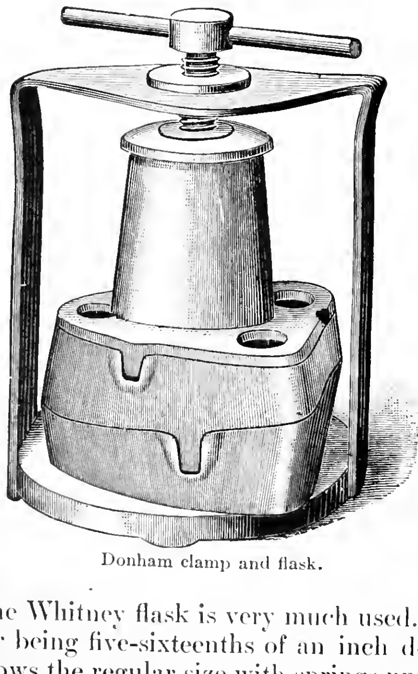
a correspondingly wide rim in the upper section. It is designed to be used for full cases only and with the Donham spring clamp. (Fig. 463.) The Donham flask is shown in the Donham spring clamp. (Fig. 464.)

Fig. 463



Wilson flask.

Fig. 464



Donham clamp and flask.

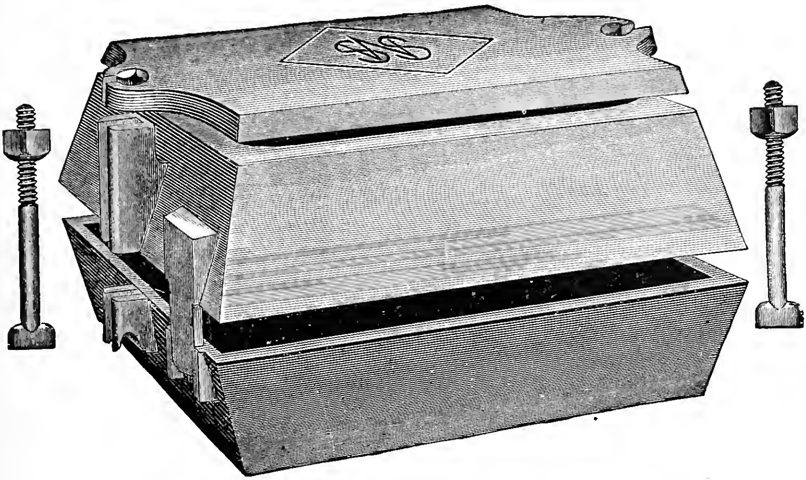
Fig. 465

Whitney flask.

The Whitney flask is very much used. There are two sizes, the larger being five-sixteenths of an inch deeper than the smaller. Fig. 465 shows the regular size with springs upon the bolts to aid in closing the flask.

The box flask is designed for interdental splints and any extra large pieces of vulcanite. It is made in two sizes, one as large as can be used in a two-flask vulcanizer and the other for the three-flask vulcanizer. (Fig. 466.)

Fig. 466



Box flask.

Fig. 468

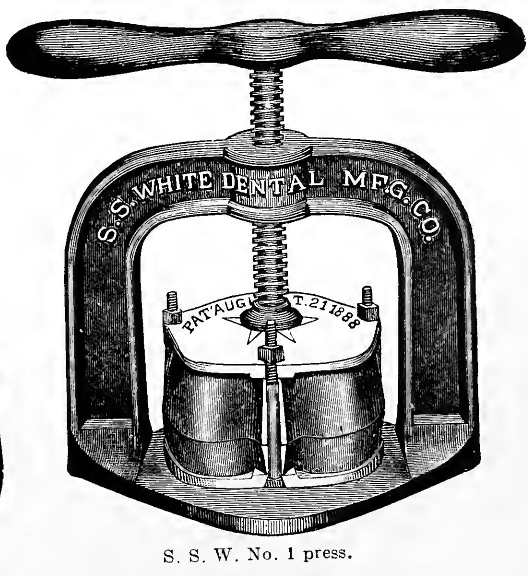
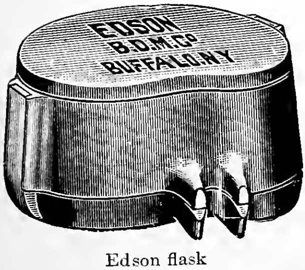


Fig. 467



Edson flask

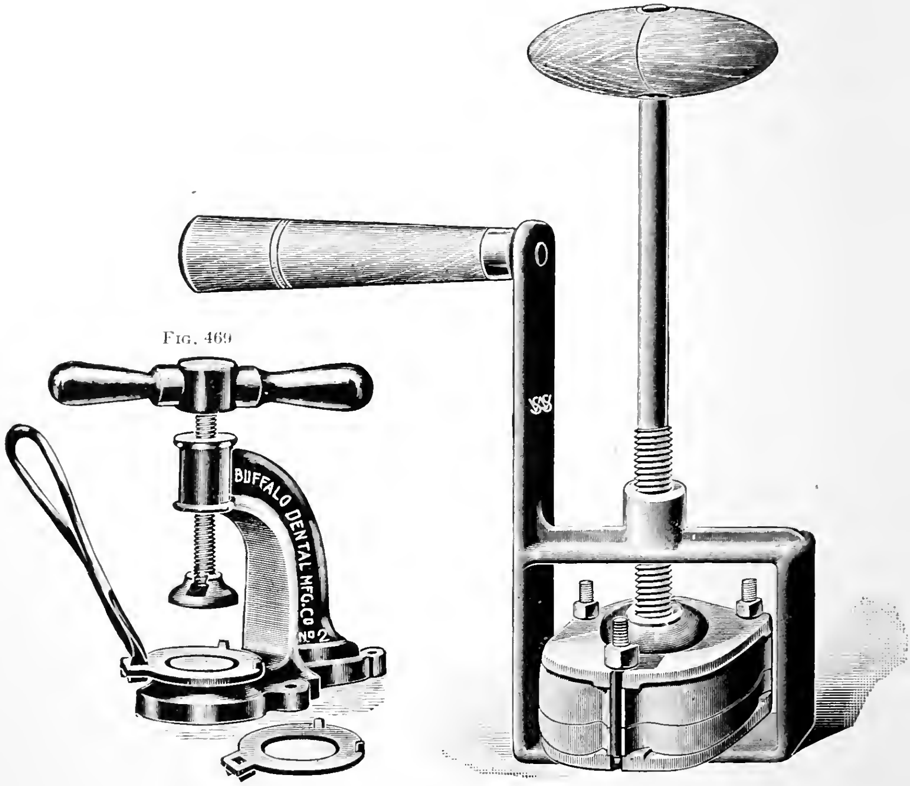
S. S. W. No. 1 press.

The Edson flask is especially designed for the Edson vulcanizer, and may be used for both vulcanite and celluloid. (Fig. 467.)

Flask Presses.—The flask press is an indispensable appliance in a well-equipped laboratory (Figs. 468, 469, 470), and yet probably its improper use has caused more misfit vulcanite dentures than all other causes. When the principles involved in the flask press and its use are understood, there should be no trouble in handling it. All

Fig. 470

Fig. 469



Buffalo No. 2 press.

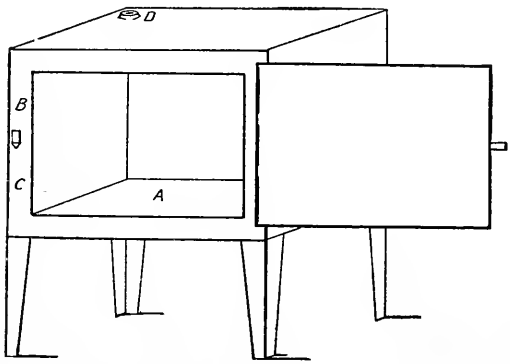
Dr. E. Wilson's press.

plasters expand and are compressible, some excessively so. French's regular dental plaster is the best and most commonly used by the profession, so these statements are in connection with this plaster. A molar tooth one-half inch in diameter under a thousand pounds pressure would be driven into well set plaster one-twentieth of an inch. Rubber when cold is very tenacious and will resist a very heavy pressure for a short time, but will gradually yield. Plaster compresses to its full extent in a very few seconds. It is easy to comprehend that if an excess of rubber is placed over the teeth upon one side, and heavy pressure is applied, that the teeth will be driven into the plaster encasement and consequently the teeth upon that side of the denture will be too long. It can also be comprehended that if the cast is formed of regular plas-

ter, and excessive rubber and pressure be applied to the vault of the cast, that it will be pressed upward and the plate warped.

We shall now consider the power of the press. The screw is a combination of the lever and wedge, and its power is calculated by multiplying the circumference described by the lever by the pitch of the screw. The Buffalo Dental Manufacturing Co. No. 2 press, Fig. 469, has a handle eight inches long, hence describes a circumference of twenty-five plus inches. There are ten threads to the inch, hence a pitch of one-tenth of an inch. An allowance must be made for friction in the screw, but one-fifth will be very liberal, when we shall have for every pound of force applied at the end of the handle, two hundred pounds pressure under the screw or a ton for every ten pounds of force. If the force is applied at the middle of the handle it will produce one-half as much pressure, or a ton for every twenty pounds of force. It is now easily understood why plates are warped, and these heavy malleable iron presses are sometimes broken. The student should now return to the Double Vulcanization Process, and read again how to use the press.

FIG. 471



Warming oven.

Flask and Rubber Warming Oven.—Fig. 471 shows a convenient arrangement for the purpose. It consists of a double box, 12 inches wide outside and 9 inches inside measurement, by 9 inches outside and 6 inches inside in heigth, the depth of the oven, (A), may be 12 inches. The space, (B), an inch and a half wide, is partly filled with water, (C). The strips of rubber to be used in packing may be laid on the top to be softened while the flasks are heated in the oven, which, as will be seen by the illustration, is provided with a door. The screw-cap, (D), is for convenience in filling the box with water, and is provided with a small hole for the escape of steam. The box should be made of copper and may be heated by a small Bunsen burner.

Vulcanizers.—There are in use at the present time many forms of vulcanizers. It would be unnecessary to enumerate them all. These descriptions will, therefore, be confined to some of the best and simplest examples of the somewhat extensive list.

Cam-lock.—This is one of the new cross-bar vulcanizers. It is very simple in construction and is expeditious to handle. It is fitted for either gas or oil. (Fig. 472.)

Fig. 472

Cam-lock vulcanizer.

Edson.—This is an older form of screw-cap vulcanizer. It has a screw press within the boiler, and is suitable for both rubber and celluloid. It is not as easy to handle as the cross-bar variety. (Fig. 473.)

The Lewis Cross-bar Vulcanizer (Fig. 474) is entirely new in its essential parts, and embodies many valuable improvements, and is probably one of the strongest, safest, and most convenient vulcanizers of the cross-bar pattern in use.

The boiler is hand-made from copper, rolled expressly for this form

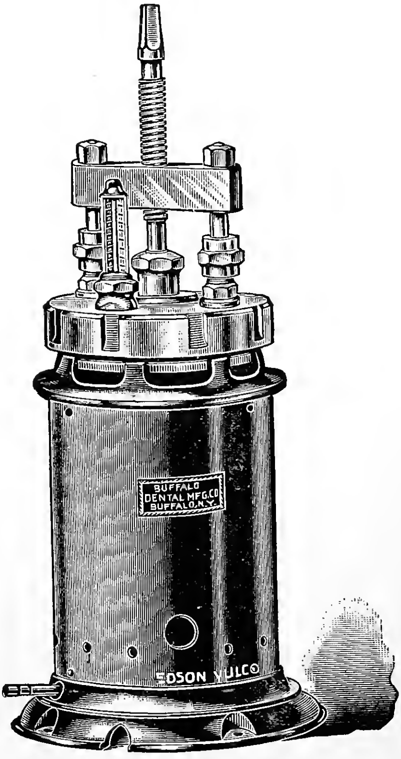
of vulcanizer, and is of unusual thickness. The cap is ribbed on the under side to resist any strain which may be put upon it. This cap has but two holes drilled in it, one for the mercury bath, to which the thermometer is attached; the other for the "manifold," which carries the safety-valve, blow-off, gas-regulator, or steam-gauge (Fig. 475.) The ring surrounding the boiler is of cast steel, and is therefore of ample strength. Beside the lugs for taking the strain off the cross-bar and bolt, it has a dovetailed projection for the insertion of a lifting handle (Fig. 476.)

It will be observed that when the cross-bar and cap are removed, there are no swinging bolts or attachments to the pot.

The cross-bar is of an improved form, and is made of cast steel. One end is at right angles to the main bar, and terminates in projections which catch under the lugs on the ring. Over the projections is a small rib which prevents the bar from dropping out of position. The other end of the cross-bar has an enlarged portion for the reception of the bolt, and is terminated by a handle.

The vulcanizer is closed by one bolt suspended in a slot on the hand-end of the cross-bar. The bolt is squared to prevent rotation, and is surrounded by a spring for the purpose of disengaging it from the lugs when the nut is loosened, and for always retaining the bolt perpendicularly and forcing it in place automatically.

Fig. 473



Edson vulcanizer

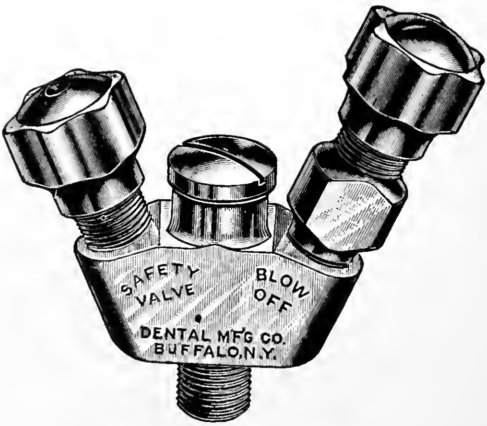
The vulcanizer is opened by loosening the nut on the bolt by means of the wrench furnished for the purpose (Fig. 477.) The bolt will be forced downward through the action of the spring. The handle of the cross-bar is then seized, and with the thumb against the nut it is pressed until the bottom of the bolt is disengaged from the lugs, when the bar may be lifted (Fig. 478.)

The Seabury Vulcanizer.—This apparatus is so arranged that the vulcanizing is accomplished with dry steam. It has a dry chamber or oven for vulcanizing, which is distinct from the steam-generating chamber or boiler, the two being connected by a valve cut-off. The vulcanizing chamber has a capacity of three flasks. In the illustration the

Fig. 474

Lewis cross-bar vulcanizer, with gas heating apparatus.

Fig. 475

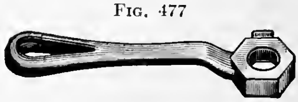


Manifold with safety valve and blow-off.

Fig. 476

Pot-lifter.

Fig. 477



Cross-bar wrench.

jacket is cut away to show the relative positions of the two chambers, and their connection. It is claimed for this machine that plates made

FIG. 478

Removing Lewis cross-bar from pot.

FIG. 479

Seabury vulcanizer.

in it are as strong when only half as thick as those vulcanized in the ordinary way. (Fig. 479.)

By cutting off the steam from the generating chamber, cases can be removed and others inserted without loss of time, and, as the plaster is but slightly injured by the dry steam, warping of plates by the yielding of the investment is not likely to occur.

INSTRUCTIONS FOR THE USE OF THE TIME REGULATOR.

"The gas regulator (Fig. 480) is secured to the cap by means of the short iron pipe or coil. This is screwed into a hole drilled through the

Fig. 480

Gas regulator.

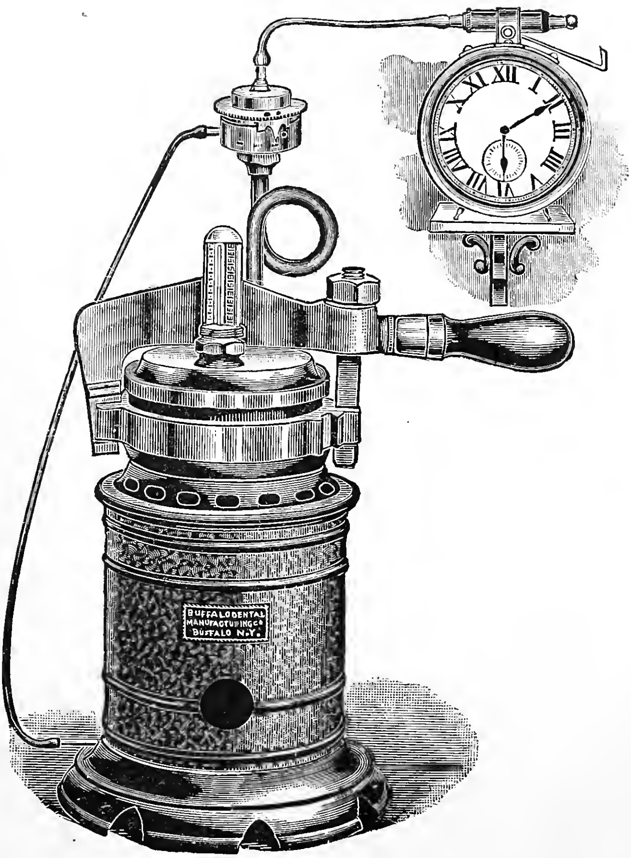
cap of the vulcanizer, and tapped with a 'one-eighth gas-pipe tap.' If the vulcanizer has a 'Lewis manifold' attached to the cap of the vulcanizer, remove the screw between the blow-off and safety-valve and screw the coil-pipe in its place. After the gas regulator has been properly fitted, place the vulcanizer in the jacket and in the position in which it is to be used. Connections between the time regulator, gas regulator, and gas burner are made by means of rubber tubing. The engraving (Fig. 481) illustrates the correct method of connecting gas and time regulators to vulcanizers. Cut a piece of tubing of sufficient length to reach from the gas-supply tap to the *time regulator*, and connect them; cut off another piece to reach from the time regulator to the *gas regulator*,

and attach to the gas regulator by the *upright* or straight nipple on top of the No. 4 Lewis gas regulator; then connect the downward curved tube of the gas regulator to the gas burner under the vulcanizer with another piece of rubber tubing.

"The time regulator is more convenient when placed on a bracket near the gas-supply pipe. It is then out of the way, and not likely to be broken from contact with tools, and can also be used as a timepiece.

To Set the Time Regulator.—When the valve lever on top of the time regulator (Fig. 481) is engaged with the screw upon the minute arbor on the back of the clock, the valve is held open for a length of time depending upon whether the lever is engaged with the first, second, or third thread of the screw; and the lever will be cast off, and the valve closed when the minute-hand reaches the figure XII. When the minute-hand is at IX the lever will be cast off at the end of fifteen minutes, if it is engaged with the *first* thread of the screw from the end; an hour and a quarter, if engaged with the *second* thread, and so on. A trial

Fig. 481



No. 4 graduated gas regulator, mounted on a Lewis cross-bar vulcanizer.

should be made, and the time ascertained which is necessary for heating the vulcanizer to the vulcanizing point, and this time should be added to the proposed time for vulcanizing. We have, therefore, the following:—

"RULE.—Turn the minute-hand to as many minutes *before the hour* as the number of odd minutes desired; then put the end of the lever in the threads of the screw upon the minute arbor at the back of the clock. The *first* thread from the end gives the odd minutes to which the clock is set; the *next* and *each* succeeding thread gives a full hour. For example: For an hour and twenty minutes, set the minute-hand at the figure VIII, and engage the lever in the *second* thread from the end of the screw. At the end of that time the lever will disengage and automatically shut off the gas from the vulcanizer. If this were to be an hour longer—*i. e.*, two hours and twenty minutes—the lever should be placed on the third thread of the screw. For three hours, set the minute hand at XII and the hour in the third thread of the screw lever.

"Those who use vulcanizers should be thoroughly informed as to the nature and properties of steam. The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam boiler, which it is in fact, and, although it is comparatively safe and easily operated, it may, by carelessness or ignorance in its management, become exceedingly dangerous.

"The following table of steam-pressure will be found convenient for reference, as it has been corrected so that it shows the true temperature for any pressure indicated by the steam-gauge. Fractions are omitted, and the nearest whole number is used instead. The French table generally used shows 14.7 pounds pressure at 212°, whereas the steam-gauge at that temperature will indicate 0, unless by the expansion of heated air confined in the vulcanizer. The guage is therefore just *one atmosphere* lower than French table:

Table of the Elastic Force of Steam[1] *(corrected to correspond with the steam-gauge).*

Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.	Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.
212	0	390	205
220	2	400	234
230	6	410	264
240	10	420	296
250	15	430	335
260	21	440	375
270	27	450	415
280	34	460	455
290	43	470	515
300	52	480	565
310	63	490	603
320	75	500	663
330	89	510	721
340	104	520	793
350	120	530	864
360	140	540	937
370	160	550	1015
380	180		

[1] General instructions for operating dental vulcanizers, Buffalo Dental Manf'g Co., July, 1898

"It will be noticed that as the temperature rises the pressure of steam increases in a constantly increasing ratio for equal increments of heat, the pressure being nearly doubled by the addition of fifty degrees to the temperature. This fact will show the *necessity* of care and watchfulness while vulcanizing.

"The bulb of the thermometer is set in a mercury bath. This is the small cup, forming a part of the vulcanizer cap, to which the thermometer case is screwed. This cup should contain sufficient mercury to ensure its touching the bulb of the tube when the thermometer case is screwed down properly. This makes a *metallic connection* between the thermometer bulb and the vulcanizer cap, and is *absolutely necessary* for the proper indication of heat by the thermometer.

"Should the mercury column separate, it can usually be reunited by removing the tube from the thermometer case, holding it perpendicularly, and striking the bulb with some force upon the palm of the hand, or by holding the tube by the bulb and giving it a sudden flirt. If the vulcanizer is used with the thermometer in this condition, it should be remembered that it is the *whole column* that denotes the heat, and allowance should be made for the broken part; *i. e.*, if there is enough mercury separated to fill the space of ten degrees, the remainder of the column should only rise to ten degrees less than the temperature desired.

"Directions for inserting a new tube in the thermometer case will generally be found on the package containing the tube and scale.

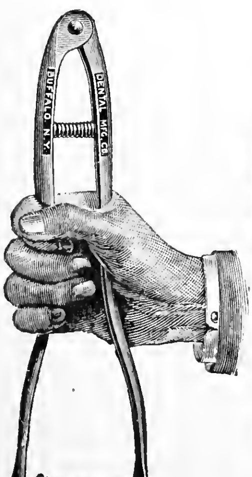
"Thermometers are accurately marked, by test instruments, at the 212° and 320° points, and the scales are especially graduated for each tube, as the positions of the points above named vary in different tubes. *Each tube must, therefore, be used with its own scale,* and in fitting it to the case, care should be taken that the black mark on the tube indicating the 320° point is brought exactly opposite to the 320° point on the scale.

"The thermometer does not always give a correct indication of the heat of the vulcanizer. It only gives the temperature of the vulcanizer top, which may not be that of the flask. In fact, the indications of the thermometers employed on vulcanizers are almost invariably too low, owing to imperfect conduction of heat, radiation, etc.; and the vulcanzation temperature, instead of being 320°, as indicated, is more usually 330° to 340°."

The plan of providing a mercury bath for the reception of the bulb is a great improvement over the old way, and prevents the fracture of the bulb by the great pressure of the steam, which was of such frequent occurrence when the thermometer was in direct contact with the latter.

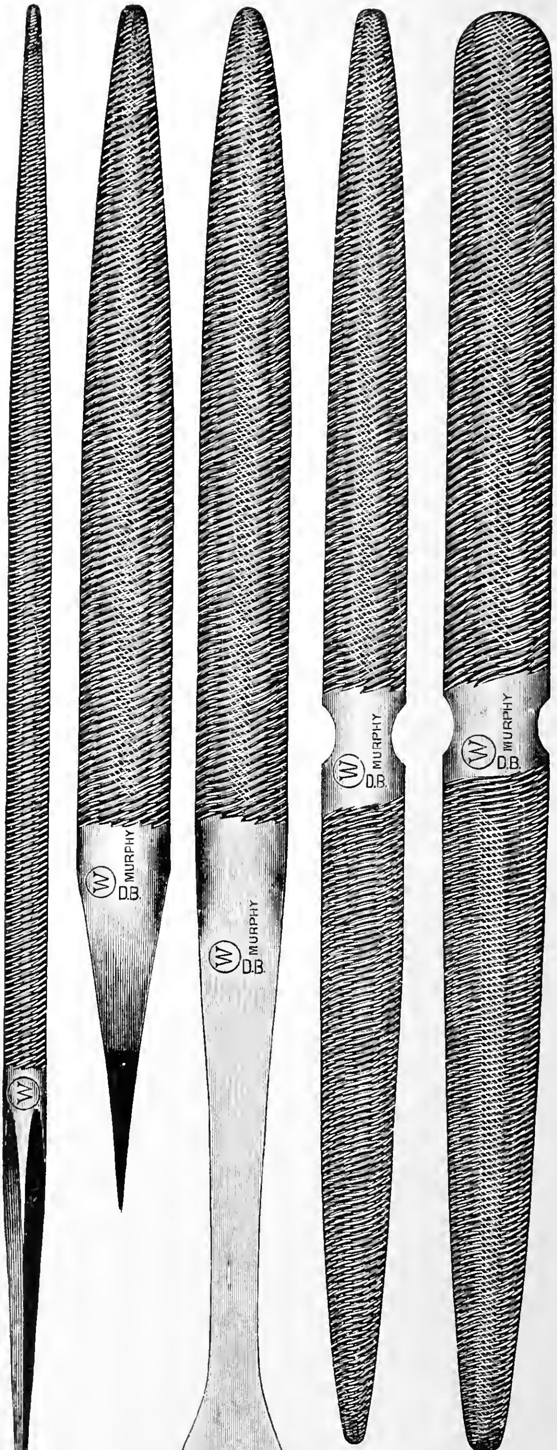
Damage to the glass bulb of the thermometer is manifested by a rise in the mercury, which cannot be brought down to the usual vulcanizing point by turning off the flame of the burner; consequently the thermometer ceases to correctly indicate the degree of heat, and imperfect vulcanization is the result. Leakage of steam around the packing of the vulcanizer should also be guarded against, as in such cases all of the water may escape from the apparatus before the vulcanizing is complete. Loss of all of the water in the vulcanizer may be detected by a per-

FIG. 482



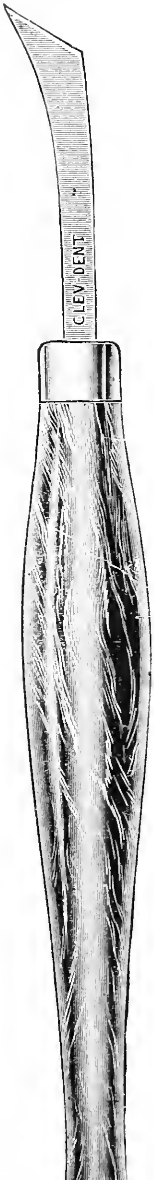
Flask-tongs.

FIG. 483



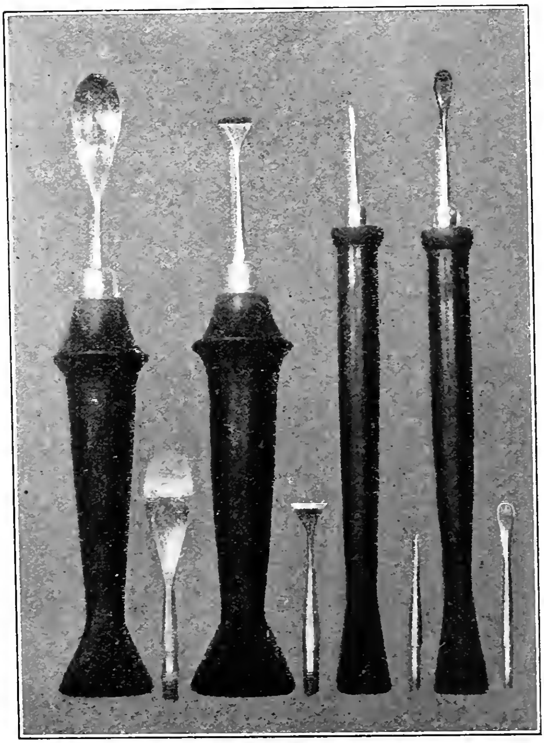
Vulcanite files.

Fig. 484



Spaulding trimmer.

Fig. 485

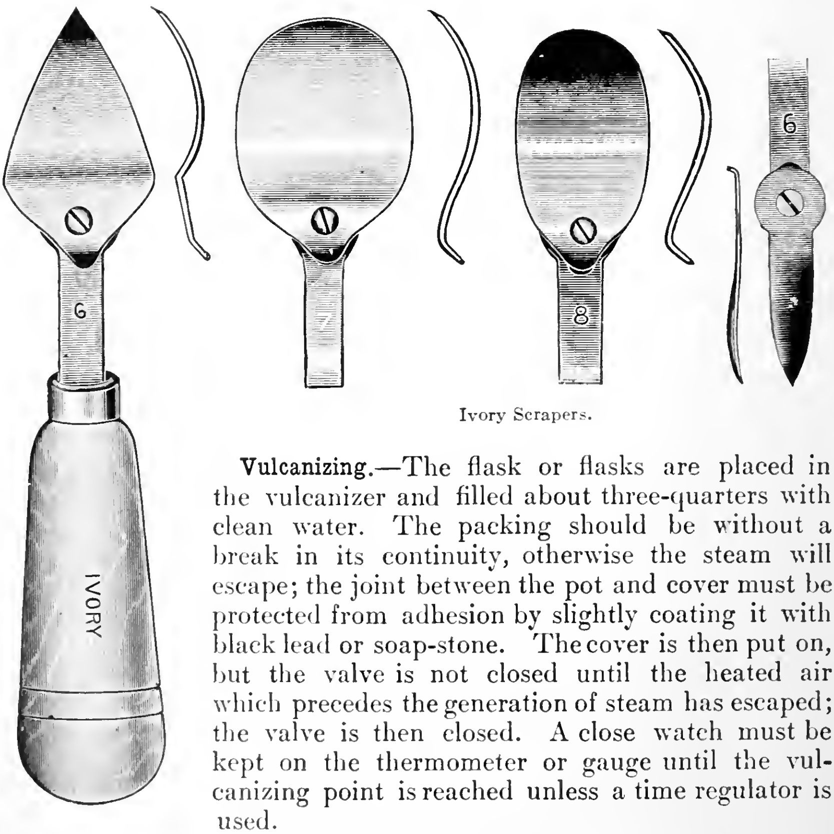


Wilson set.

sistent fall of the mercury, even when the gas flame is greatly increased, and when this phenomenon is observed, the gas should be turned off, the vulcanizer allow to cool, and new packing adjusted.

Failure to strictly observe this rule has undoubtedly resulted in many serious accidents. An example of this kind occurred some years since in the laboratory of the Dental Department of the University of Pennsylvania. A student was endeavoring to vulcanize with an apparatus which leaked at the packing: noticing that the mercury persisted in falling, he continued to increase the gas flame until the lower part of the vulcanizer was probably red hot. While he stood before it, holding a lighted match to the tube to enable him to see the column of mercury, the vulcanizer exploded with terrific force, sending the top through the ceiling and pieces of the boiler in every direction. It is quite likely that in this particular case the steam was partly decomposed by contact with the hot metal, producing a highly explosive combination of oxygen and hydrogen: no other theory would seem to account for the great force of the explosion.

Fig. 486



Ivory Scrapers.

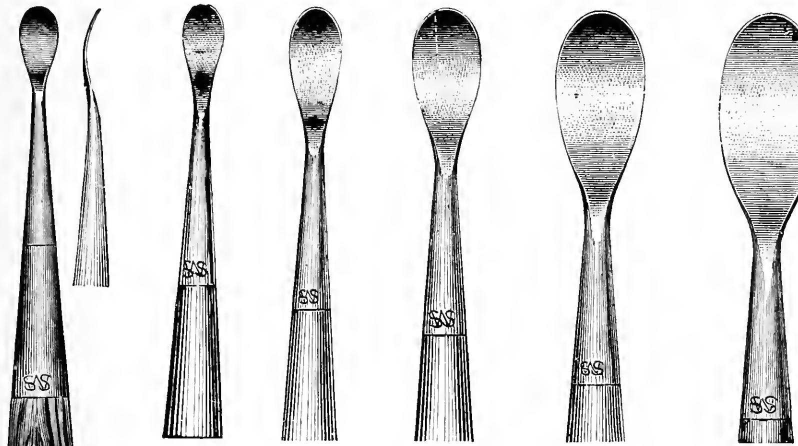
Vulcanizing.—The flask or flasks are placed in the vulcanizer and filled about three-quarters with clean water. The packing should be without a break in its continuity, otherwise the steam will escape; the joint between the pot and cover must be protected from adhesion by slightly coating it with black lead or soap-stone. The cover is then put on, but the valve is not closed until the heated air which precedes the generation of steam has escaped; the valve is then closed. A close watch must be kept on the thermometer or gauge until the vulcanizing point is reached unless a time regulator is used.

Flask-tongs.—Figs. 482 shows a useful form of flask-tongs for lifting flasks from the vulcanizer. They are made of sufficient length to reach the bottom of a three-case vulcanizer, and will securely grip the flask

Files.—Fig. 483 illustrates some excellent forms.

Scrapers.—There are a great variety of scrapers and chisels from which each operator may select such as seem best adapted to his hand. The writer's preferences are the ones here illustrated.

FIG. 487




Kingsley scrapers.

OCCASIONAL AND SPECIAL METHODS.

Gum Section Teeth.—There are two varieties of teeth used for the vulcanite base. They are known as plain and gum section teeth. The plain teeth are single and have no porcelain gum, but may have a reproduction of the neck portion of the root of the tooth. The gum sections may be single teeth with a porcelain gum, but usually they are in the form of blocks, each containing two or three teeth. There are various combinations of the teeth in the blocks designed to meet special cases. The plain teeth are used only for the double and single vulcanization methods as previously described, but either plain or section teeth may be used for the single vulcanization sub-method. The gum section teeth require much grinding to adapt them to the wax or hard gum base-plate. The joints between the blocks must be ground to fit squarely against each other and not with a V-shaped space. The case should be flasked at the periphery of the wax. Much care should be used in packing and closing the flask. Do not use too great pressure, as there is danger of checking the porcelain gum and of opening the joints.

Advantages and Disadvantages of Section Teeth.—Where the gum portion must be restored and there is extreme mobility of the lip, the porcelain gum will appear to better advantage than the vulcanite gum

restoration. In partial cases, blocks of one to four teeth can sometimes be used to very great advantage.

The disadvantages are: (1) the forms of the sections preclude the possibility of the individualizing of the teeth by the dentist, they always have a stiff, unnatural appearance; and (2) there is a space between the porcelain and vulcanite for the accumulation of filth. This last objection does not apply to most of the partial cases requiring gum section teeth, because in these cases the gum portion is not backed up with vulcanite. Some years ago the gum section teeth were in almost universal use, but to-day there are sections of the country in which sets of fourteen gum section teeth are rarely used.[1]

Plain Teeth Without Gum Restoration.—Many cases of recent extraction and in a few cases where the gum is sufficiently full after resorption has taken place, no restoration of the gum is required. In these cases the plaster of the cast is scraped away one thirty-second of an inch for the insertion of the cervical end of the teeth. Without this precaution the teeth in the finished denture would not set closely nor appear to grow from the gum.

Black Rubber Single Vulcanization Method.—Some people fear the effect of the coloring matter in red rubber, so that it may be desirable to construct the denture of black rubber, when it becomes very necessary that the black rubber should not show upon the labial and buccal surfaces. The two rubbers can be packed in the usual way or by this very ingenious method.[2]

Dr. Slabaugh's Method.—"After separating the flask and boiling out the wax, I coat the cast with silex and then lay on my black or red rubber loosely over the cast. I then take a piece of the cloth that comes on the sheets of rubber and lay it over the rubber that is on the cast, and place the two parts of the flask together and set them in boiling water for a few minutes, after which I place the flask in a press and force it together, care being taken to have the flask entirely together. The flask is entirely filled with the rubber. I now separate the flask and the rubber will adhere to the cast. Remove the cloth that has been put on and you will have perfect imprints of the teeth and pins in the rubber that have been made through the cloth. I then place a narrow strip of pink rubber on the black or red over the imprints of the teeth and up to about one thirty-second of an inch of the imprint of the pins. Place the two parts of the flask together and force them down and it is ready for the vulcanizer. Cut waste gates only in the rear so that when the flask is closed the second time with the little piece of pink rubber added to it, the slight displacement of black or red rubber will be entirely toward the rear."

Waxable Rubber.—Recently this material has been placed before the profession by John Hood & Co., Boston. Its physical properties are very much like those of sheet gutta-percha. It is not a patented

[1] The writer has put up but one set of gum section teeth in nineteen years.
[2] Dr. Frank W. Slabaugh of Omaha, Neb.

article. The claims for the material and the method of construction are given as follows: "An entirely new process with a material far superior to rubber,—much lighter and one that will not become slimy in the mouth. To use, hold a sheet over the burner the same as a sheet of wax and make a trial plate; build out with rubber to the desired fulness and put the teeth in place with a spatula, by keeping the rubber soft and heating the tooth. Use the rubber just as you do wax, and smooth it before adding pink rubber. After it is cool, add the pink rubber by first removing the teeth without heating, leaving the impression of the teeth in the rubber. Cut a strip of pink rubber wide enough to reach the ridge and cover the indentations of the teeth, just above the pin holes, and to reach from heel to heel. Soften the rubber slightly and heat the tooth and replace it, carrying the pink rubber under the neck of the tooth. In this manner you can make a natural festoon as full as is desired. Care should be taken not to make any finger-nail marks or to mar the pink rubber. After the teeth have been tried in, before placing on the cast, paint the cast with the solution and heat the plate, pressing it in place with the fingers. Smooth the red rubber by the use of chloroform on a cloth. Moisten the cast and drive the air from it. Fill the flask with plaster and press in cast, shaking the flask well to prevent bubbles. Vulcanize, taking twenty-five minutes to run up, and then hold it one hour at 315 degrees."

Thick Vulcanite.—Thick masses of rubber may be vulcanized by gradually increasing the heat from 280° F. to 300° F. (See "History of Vulcanite" in the early part of this chapter.) Another method is to fill the mold with vulcanite, having the rubber packed about it; or the mold may be largely filled with pink rubber.

REMOVING THE TEETH FROM A VULCANITE PLATE.

Sheet Iron Method.—Place the denture, teeth downward, upon the sheet iron over a gas stove, and when the vulcanite is thoroughly softened, the teeth may be pushed off one at a time by inserting the wax spatula between the tooth and the vulcanite upon the lingual side. The plate is held by a pair of pliers and the dislodged teeth are permitted to fall upon wood, or better, upon cloth, but not upon cold iron or stone. Any portion of the vulcanite remaining about the pins should be removed. If necessary, these small portions of vulcanite may be softened by grasping the tooth in a pair of solder tweezers and holding in the Bunsen flame.

Glycerine Method.—The denture is placed in a vessel of glycerine and heated to the boiling point of the liquid, when the teeth can be removed as in the other method. The glycerine is soluble in water and easily removed. The fumes of the heated glycerine are more objectionable to some than those of the overheated rubber.

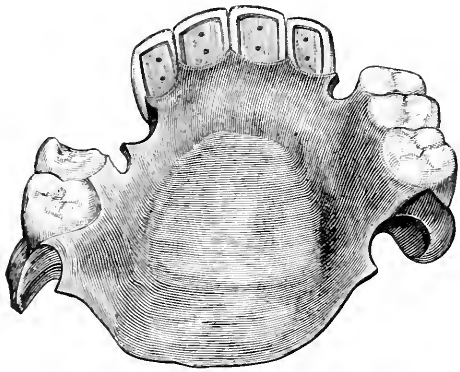
Flame Method—The denture is grasped with a pair of pliers and the outer surface of the teeth heated by passing repeatedly through the

flame until the vulcanite is softened about the pins, when they are removed as before described.

It is not advisable to remove the teeth by heat from a denture which is to be used again, because of the liability of warping the plate. The vulcanite should be cut from about the pins of the tooth with a bur in the engine or with a chisel.

Partial Cases.—It frequently occurs in constructing partial artificial dentures for the replacement of single incisors or canines that the ordinary rubber teeth are too thick to admit of their being arranged to conform to the line of the natural teeth without interfering with the normal

FIG. 488



Partial vulcanite plate arranged for case with marked overbite.

occlusion (Fig. 488). In such cases a plate tooth may be used, and is attached by means of gold backings, bent at an angle with the base of the tooth, of sufficient length to allow of the projecting portion to be imbedded in the rubber plate, as shown in Figs. 488 and 489. The extension of the gold backing shown in Fig. 489 has two or more holes punched and countersunk in it, so as to be held firmly by the vulcanized rubber.

FIG. 489

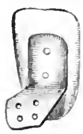


FIG. 490

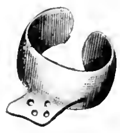


FIG. 491

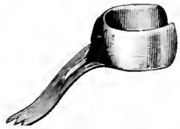
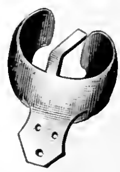


FIG. 492



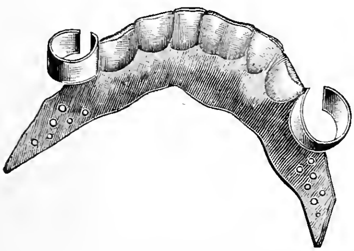
Tooth and clasps prepared for attachment to vulcanite plate.

Gold Clasps.—Gold clasps, when used in combination with rubber, are attached in the same way. The clasp, after being accurately fitted to the plaster tooth, is provided with a piece of gold plate soldered at a point next to the rubber plate (Figs. 490–492). This attachment should be slightly raised from the cast, so that it will be entirely enveloped by the rubber, as shown in Fig. 490.

There is some danger of these clasps being forced slightly from their correct position by the pressure of the rubber in packing. This difficulty may be entirely overcome by soldering a temporary support of scrap gold to the clasp and bending it over the plaster tooth, as shown by Fig. 492. Usually this device will be found effective in retaining the clasp in contact with the tooth. After vulcanizing, the supporting piece of gold may be sawed off with a jeweler's saw. In packing a case arranged with gold clasps, a thin sheet of rubber should be worked under the gold attachment to further protect the latter from displacement. It will, of course, be understood that the clasps are to remain in position during the packing; therefore, in flasking such cases the plaster should be made to cover the portion of the clasp not actually in contact with the rubber; this affords additional support to the clasp during the pressure accompanying the closing of the flask in packing, and will keep it in correct relation to the plaster tooth.

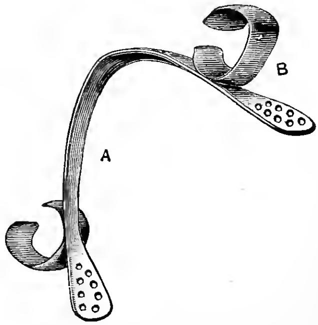
Partial Lower Vulcanite Dentures.—Gold is used in combination with that class of partial lower dentures designed to replace the bicus-

FIG. 493



Strengthener of clasp gold to be used in connection with vulcanite.

FIG. 494



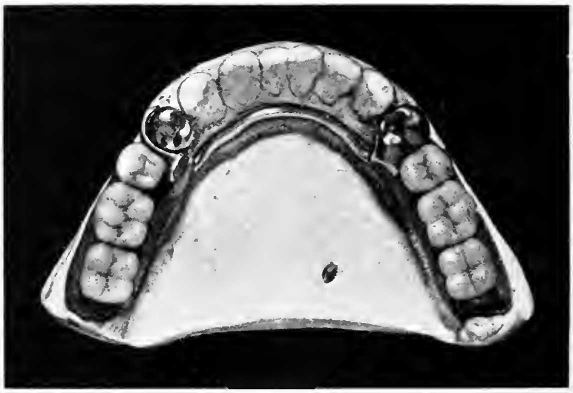
Strengthener and clasps for lower plate.

pids and molars and when the natural incisors and canines remain. For the purpose of strengthening the piece and to lessen its bulk in front a plate of gold is sometimes swaged to fit the cast back of the front teeth, and where the ridge is not well defined and not favorable to the retention of the piece without some form of attachments, gold clasps are soldered. The gold plate is allowed to extend somewhat beyond the canine teeth; the ends are perforated by the punching forceps, as shown by Fig. 493, to ensure strong union with the rubber. This plate is then put upon the cast and secured in place by means of wax; the teeth are arranged in position, waxed up, and vulcanized in the usual way. The denture when finished presents to view a plate with the anterior part of gold, while the two parts holding the teeth and resting upon the ridge on each side are of vulcanite. The purpose of such a combination is to save labor and material, but a denture so constructed, while better in point of durability and because of the absence of bulkiness where it

passes around back of the incisors and canines than vulcanite alone, is still far inferior to one constructed entirely of gold, for while such a denture is doubtless stronger than one of vulcanite alone, it is not so durable as one made exclusively of gold, on account of the liability of the piece to break at the points where the gold is imbedded in the vulcanite. Dentures of the class above referred to should always be made entirely of metal, and the expenditure of money and labor is but little greater than in the combination plan, while the general result is in every way more satisfactory.

Dr. P. T. Dashwood uses in place of the swaged plate above suggested for the anterior portion of lower partial dentures, an iridio-platinum wire, gauge 14, which is bent with round nosed pliers to conform to the lingual alveolar surface. The ends are flattened upon an anvil and cross pieces of platinous gold are soldered to them for the attachment of the vulcanite. He makes the just claims that the wire is "stronger than vulcanite, is much more comfortable to the patient, and is more hygienic."

Fig. 495



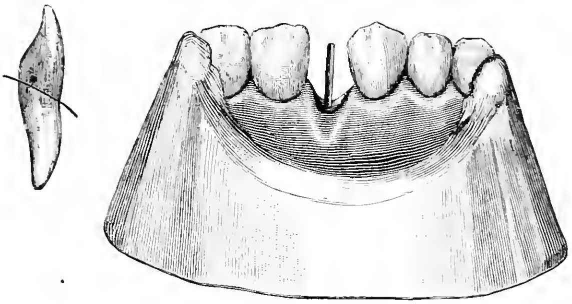
Completed plate.

Natural Teeth upon Vulcanite Base.—Where the anterior natural teeth have become so loosened by the ravages of pyorrhœa alveolaris, by excessive resorption of the gums and sockets or of the roots of the teeth, so that their complete loss is a matter of a very short period of time, a plaster impression may be taken of the mouth before the removal of the loose teeth.

In constructing partial dentures for cases where the natural organs are prematurely lost, it is much the better practice to reset the natural teeth, provided, as is often the case, they are of dense structure and have not previously been attacked by caries. This is done by making a plate in the usual way, and in the spaces to be occupied by the natural teeth vulcanizing a strong platinous gold wire, being careful to place the gold pin in the centre of the space. The wire must have an attachment soldered to it, so that its connection with the rubber will be secure. The wire may be arranged with a simple piece of scrap gold

soldered to the end to be imbedded in the rubber, as shown in Fig. 496, or it may be provided with a perforated extension, as shown in Fig. 497, by which union with the rubber may be secured and great bulkiness avoided. The rubber portion of the denture finished, it only remains to remove the infirm natural organs and attach them to the plate made ready for their reception. This is done by sawing off the roots (Fig. 496), enlarging the pulp-canal with a suitable engine drill, fitting

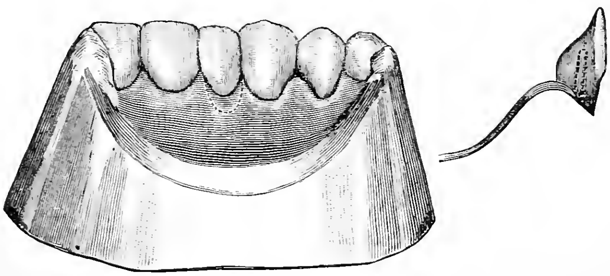
Fig. 496



Cast with plate in position: natural tooth to be added.

the neck of the tooth to the plate, and into the socket, as shown in same figures, and then attaching the tooth to the pin (Fig. 497) and plate by means of zinc-phosphate cement, being careful to dry the parts thoroughly before the cement is applied. This method of resetting natural teeth is more conveniently done on gold plates than on those of rubber, but it is applicable to both. It possesses the following advantages:

Fig. 497



Natural tooth mounted upon plate.

First. The teeth are the patient's natural teeth, and this fact very greatly lessens the repugnance which many individuals of exalted sensibilities feel to artificial teeth. Second. It saves the individual from being seen without teeth—a matter of the greatest importance to many patients. Third. Artificial appearance is avoided, for they are the natural teeth of the patient, and nothing more need be said on the score of natural effect. The question is often asked, Do teeth reset in this manner suffer from dental caries? It has been observed that such teeth

are not more liable to decay after their attachment to a plate than they were before removal from their sockets.

If the infirm natural teeth are of poor quality and have large fillings in them, it is better to use porcelain teeth, and the dentures can be entirely finished ready for insertion before the natural teeth need be extracted. Care should be observed to allow the necks of the artificial teeth to extend well into the sockets of the extracted organs, to anticipate resorption of the parts which to some extent is sure to occur at such points.

Combination Dentures.—Under this heading are included metal plates with vulcanite attachments, vulcanite plates with metal linings, vulcanite dentures strengthened with perforated metal plates, etc. Excellent results may be obtained by attaching the teeth to metallic plates by means of vulcanized rubber. A denture so constructed will be found to possess greater strength than one of vulcanite alone, while it will have the additional advantage of being free from interstices, which favor the lodgment of decomposable débris. In other words, the combination of metal plate with vulcanite attachment thoroughly meets the objections raised against either method alone.

Either gold, silver, platinum, aluminum, or any of their alloys usually employed in prosthetic dentistry, may be used in the construction of one of these combination dentures; preference, however, should be given to gold as a base. Platinum unalloyed is not well adapted for the purpose, on account of its great ductility and weight, but when alloyed with a small percentage of iridium its rigidity is so much increased that a plate of No. 29 thickness will be found to be quite as strong as a much thicker plate of 18-carat gold.

Either ordinary silver plate of standard[1] fineness may be used with rubber attachment, or silver alloyed with platinum, the latter having greater tensile strength than the former. It must be remembered, however, that silver has a powerful affinity for sulphur, the indurating agent in vulcanite, and that the presence of platinum as an alloy does not entirely protect the silver from the action of the sulphur. It is, therefore, necessary, where a silver plate is used, to interpose a layer of No. 60 tin-foil between the rubber and the plate; this precaution, however, is not necessary where celluloid is used.

In silver dentures with vulcanite attachments the anchorages must invariably be made of platinum or gold wire. After the plaster wall is made and the wax removed from around the teeth, the exact positions of the anchorages are marked upon the plate with a sharp steel point to the number of eight or ten. The plate is then laid on a charcoal support and pieces of silver solder are fused at the points indicated. The wire is then cut into proper lengths, screwed in a vise, and one end of each flattened by means of a rivetting hammer into the form of a head: each pin is then taken up separately, the headed end dipped in borax, and placed on the plate at a point where a piece of solder has been fused. The borax will assist in retaining the piece of wire until the flame of the

[1] Coin.

blowpipe is directed upon it to remelt the solder and unite the pin to the plate. The wire anchorages are not to be bent into hook form, as shown in Fig. 500, until after the tin-foil protection has been adjusted. The pins are forced through the tin-foil and pressed with a rubber point and burnished closely to the plate. The holes made by the passage of the pins through the tin-foil, if care is used, will not be large enough to allow the rubber to reach the silver to any great extent. After the tin is in place the pins may be bent with pliers, as shown in Fig. 500.

Another method is by directly tinning the surface to be covered by the rubber. The silver is cleansed and covered with a saturated solution of zinc chloride. The tin-foil is pressed carefully against the silver and the plate is held above a Bunsen flame until the tin fuses. Its flowing is to be directed by means of a camel's-hair pencil which has been dipped in the zinc solution.

Vulcanite in Combination with Plates of Fusible Alloy.—For the modus operandi of the preparation of plates of fusible alloys the reader is referred to Chapter XV. The Reese or Weston fusible alloys can be cast very thin, and yet are sufficiently rigid to withstand the force of mastication. These alloys retain their color and make an admirable combination plate. Having finished the plates as shown above, the edges and raised rims are trimmed to the desired dimensions. A roll of softened modelling compound or wax is pressed around the gums over the alveolar ridges, and trimmed with a knife to the supposed height of the teeth. The plates are then tried in the mouth, and the wax trimmed from all sides until perfect occlusion and contour are obtained. The median line is marked on the modelling compound or wax, as the case may be, and the cutting edges marked in several places to serve as guides in restoring the upper and lower waxes to their correct relation with each other should they become separated. The articulating models are prepared in the usual way—pouring plaster into the lower plate, first allowing it to extend back sufficiently to receive the upper half, which is to be poured next. The modelling compound or wax is then to be removed and the teeth arranged and waxed up and vulcanized. The attachment of the vulcanite to the plate may be secured by freely nicking the ridge to which the teeth are to be fastened by means of a sharp-pointed graver, but without this the undercut of the rims and buttons will be ample to hold the vulcanite securely to the metal.

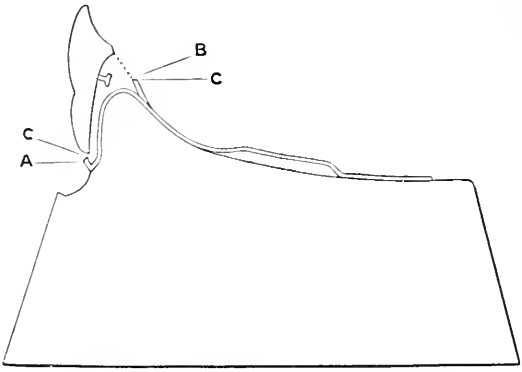
Aluminum, though not affected by sulphur, is not as well suited for vulcanite attachments as the other metals named, on account of the want of reliable aluminum solder with which to fasten the loops or pins thoroughly; but by special treatment, which will be described in connection with the manner of preparing aluminum plates, a comparatively durable denture can be made of that metal with vulcanite. Recently casting methods have been so improved as to make the use of cast aluminum with a vulcanite attachment a thoroughly satisfactory procedure.

In constructing a denture of gold with vulcanite attachments the plate should be of the thickness of No. 27 of the standard gauge, and

made in accordance with the directions for the making of gold and silver plates in Chapter XIV.

It should be provided with a rim extending entirely around the labial and buccal edges and upon the palatal portion of the plate slightly posterior to the alveolar ridge, as shown in *A* and *B* in Fig. 498. This rim may be formed of No. 27 plate (Fig. 498) or round wire of No. 17 gauge (Fig. 499). A rim formed of round or triangular wire requires

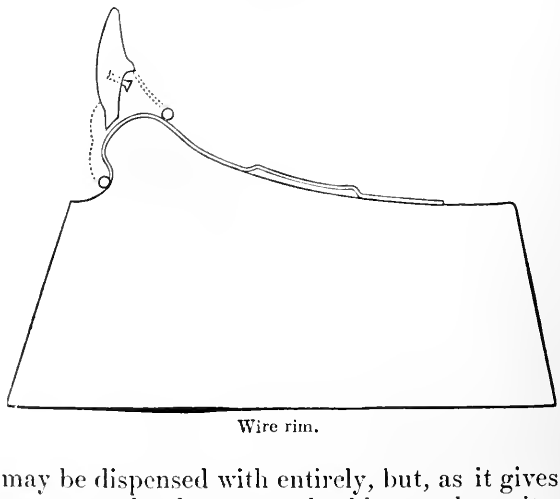
FIG. 498



Cross section of gold plate showing soldered rim.

much less labor and time in its adjustment and soldering than if formed of a strip of plate, and when flattened with the file on the labial side, and the corundum wheel and graver on the lingual side, it has the same effect as if it was formed of plate.

FIG 499



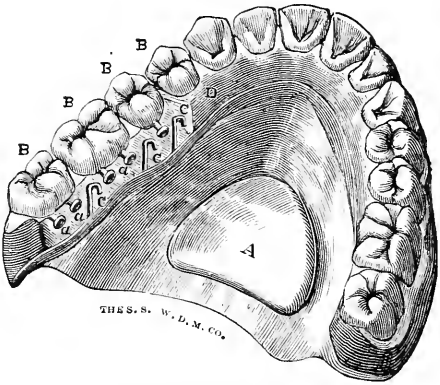
Wire rim.

The rim may be dispensed with entirely, but, as it gives a more finished appearance to the denture and adds greatly to its strength, it should, therefore, always be preferred.

In attaching a flat rim to a gold or silver plate a strip of plate long enough to extend entirely around the rubber attachment, should be cut.

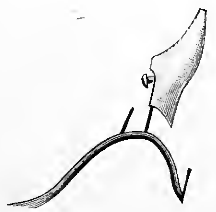
The rim should be annealed, and bent with the pliers to fit the labial and buccal edges on the plate. It is then placed on a charcoal support, and the rim held in contact with the plate by means of small nails or tacks: it is then united to the plate by a small piece of solder immediately in front at the frænum and at one or two other points along the buccal edges. The plate is then cooled, placed upon the plaster cast, and with a small hammer and pliers the rim is brought in close enough contact with the plate to admit of complete soldering. The lingual portion of the rim should not be soldered to the plate until after the correct position of the teeth has been ascertained. This is accomplished by arranging the teeth according to the bite and other requirements of the case, and then making a wall of plaster around them, separated at the centre line. This enables the operator to mark upon the plate with a sharp instrument the correct point at which to solder the rim, so that it will leave an unbroken surface for the tongue, as shown by B in Fig. 498 and to mark the proper position for the loops or bent-pin attachments, as shown by C in Fig. 500. It is very important that the exact location of these fastenings should be ascertained, but this cannot be determined until after the teeth have been adjusted. Any attempt to solder the

Fig. 500



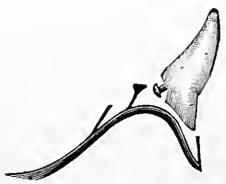
Location of wire attachments.

Fig. 501



Incorrect location of rim.

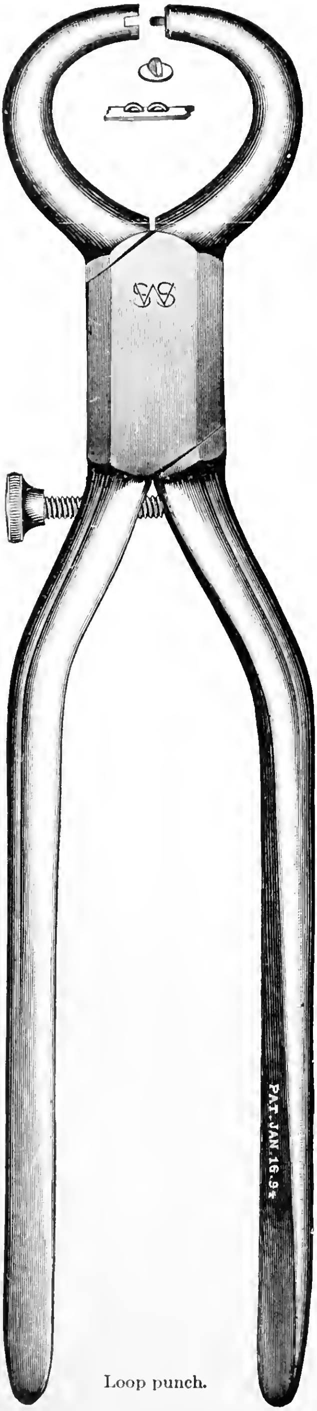
Fig. 502



Incorrect location of rim and attachment.

rim or fastenings previous to the fitting and arrangement of the teeth will be but guesswork, and nearly always result in either of the conditions shown in Figs. 501 and 502.

Fig. 503

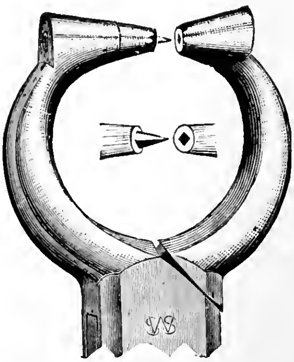


Loop punch.

The wire rim is soldered to its place by simply clamping the wire to the plate, and then attaching it at single points in front and at the buccal edges, and, after the correct position of the teeth has been ascertained, bringing it entirely around at the lingual portion, as shown by *C* in Fig. 500 By simple pressure with an instrument or gently tapping with a riveting hammer, it may be brought into close contact with the plate and completely soldered. It need not be flattened and finished until after the case is vulcanized.

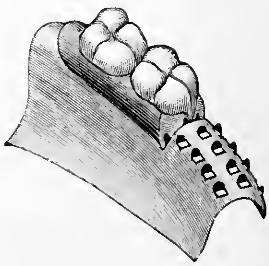
Owing to the difficulty in soldering aluminum, it is necessary to secure attachment for the vulcanite to the plate by means of perforations or countersunk holes along the top of the ridge. For this purpose ingenious perforating punches have been devised by Drs. Richmond, Peck, and others; those of

Fig. 504



Perforating forceps No. 9.

Fig. 505



Perforated plate.

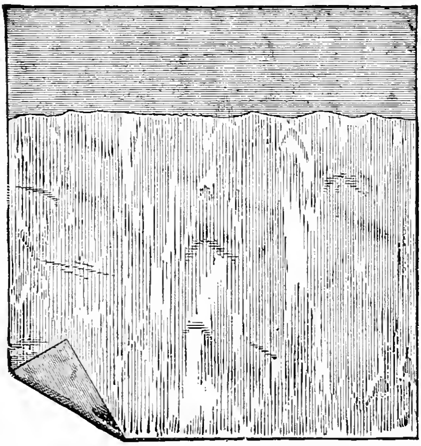
the two former are shown by Figs. 503 and 504, the latter throwing up a sharp square burr, the former a loop. The punch points entering from the under side of the plate, produce the desired result without in the least bending or affecting the fit of the plate.

A rolled aluminum plate, constructed in the manner shown by Fig. 505, and roughened by means of the punches (Figs. 503 or 504), and with the teeth attached by means of vulcanite, will afford a light, strong, and comparatively durable denture.

Vulcanite is of great value in refitting gold plates which have ceased to fit the mouth in consequence of changes by absorption following the extraction of the teeth. These changes may continue in some cases for several years after the removal of the natural organs, to such an extent finally that the denture will no longer be of service. The resorption usually occurs along the alveolar ridge, and it is a matter requiring but little time or labor to adjust the denture to a new plaster cast, fill the spaces caused by resorption with wax, invest, pack, and vulcanize the piece. Care must be observed to make countersunk perforations through the plate at points where the vulcanite is to be attached, so as to secure firm union with the gold plate.

Vulcanite Plates Lined with Gold-foil, Electro-deposits, etc.—Various experiments have been made with this class of work in the last

Fig. 506



The vulcan gold lining.

twenty-five years, with a view to developing some process by which a durable metallic coating can be given to that portion of the vulcanite denture which is in contact with the alveolar process and maxillary portion of the mouth. There are two methods. One consists in coating the surface of the plaster cast with gold by electro-deposition, by first rendering it impervious to warm water, so that it will not take up and destroy the gold bath. The surface to be electro-plated must be hard and smooth and free from all greasy substances. It must be thoroughly

coated with plumbago and painted with a solution of chloride of gold to facilitate rapid deposition over the whole surface.

The next and simplest form is to coat sheets of No. 8 or 10 gold-foil with a non-conductor on one side, or by putting two sheets together with a non-conductor—as wax, for instance—between them, and sealing the edges with wax to prevent the gold solution from penetrating between or through the sheets. A rough granular coating of gold or copper can be deposited on the exposed sides, which will ensure comparatively good adhesion with the plate after vulcanzing.

Another method is what is known as the "Vulcan gold lining." It is a pure gold sheet covered on one side with a thin coating of silver (Fig. 506.) The gold is applied in one piece to the surface to be covered, and no extra care is required in packing the flask. The lining is of chemically pure gold on one side with a thin covering of pure silver on the other. The union between the rubber plate and the gold lining is mechanical: the sulphur in the rubber acting upon the surface of the silver produces a condition of surface which favors adhesion.

This foil is of the thickness of No. 40. In applying it, the case should be packed first; the flask is then separated, and any imperfections in the casts are to be repaired with thin plaster or oxyphosphate cement. The cast is then to be painted with a thin solution of equal parts of shellac and sandarac dissolved in alcohol. When dry, coat the surface with dextrin, gum tragacanth, or damar varnish, and while still moist and sticky, press small pieces of the gold lining on to the cast, bright side down. The gold lining is first cut into convenient strips of the form of rectangles, squares, and triangles, to avoid wrinkling. The edges should slightly overlap, and the lining be kept free from varnish or any substance that would be likely to interfere with adhesion. Pressure on the granular side of the foil with a steel instrument should also be avoided. The rubber end of a lead pencil or the finger is the best means of pressing the gold into all the irregularities of the cast. The flask should then be carefully closed and the piece vulcanized.

Dr. John A. Daly, of Washington, D. C., has described a method of lining new and old rubber plates as follows: "The vulcanite denture is constructed and finished in the usual way; the surface to be covered with the gold lining is washed with soap and water until perfectly clean. A sharp-pointed instrument—excavator, knife-blade, or needle-point—is then employed to scratch or serrate the entire surface to be covered. Care must be observed to keep it clean, and the roughened part should not be touched with the fingers. A solution of ordinary dental rubber in naptha is then to be evenly painted over the prepared surface and allowed to dry to the point of stickiness. The lining of gold, which is the form of foil of about No. 60, hasone side roughened by the electro-deposition of gold. A strip of the foil is cut of sufficient size with which to form the rim, which, when in position, will enable the operator to handle the plate without soiling the rubber surface (no harm will result from handling the gold). Where there are depressions, the lining should be pressed with a suitably shaped piece of rubber eraser to the

lowest point in the plate. It should be cut in pieces of such size as will avoid wrinkling, and applied so that each piece will slightly overlap the other. All creases are to be removed by gentle pressure with an egg-shaped burnisher. The plate is then flasked in the usual way and vulcanized for twenty-five minutes at from 320° to 330° F. It will require no finishing when removed from the flask, except where the edges of the lining overlap. The laps must be removed carefully with a blunt instrument, such as a dull knife-blade, burnisher, or the finger-nail, bending them back and forward until they break.

If the plate has been worn for some length of time, it should be placed for fifteen minutes in a concentrated solution of lye or soda, and thoroughly cleansed before the surface is roughened and coated with the rubber solution.

The gold lining of Dr. Daly may be applied during the construction of a new denture by first varnishing the plaster cast, after flasking, with sandarac varnish, followed by a coating of damar varnish; and while the latter is sticky the cast is covered with the gold lining cut in pieces of about half an inch in width. The brown side of the gold, which is the roughened surface, must be up, so as to engage the rubber in packing, the rest of the operation being in every respect similar to the ordinary procedure of filling and closing the flask.

Fig. 507

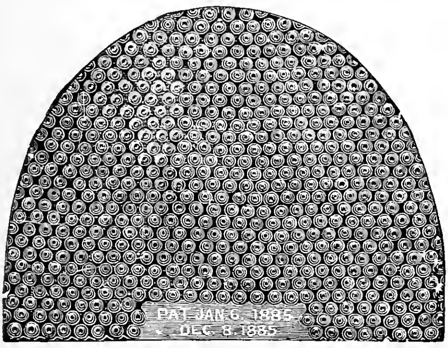
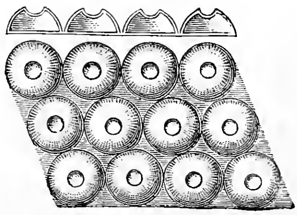


Fig. 508



Surface-cohesion forms for artificial dentures.

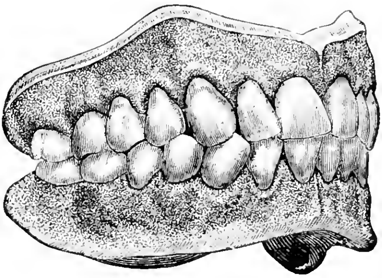
The smooth side of the gold lining is like ordinary gold foil, and is the surface intended to be in contact with the mucous membrane. The roughened surface, which has a brownish color, is prepared so as to insure strong adhesion with the rubber, and the union is said to be so firm that it cannot be stripped from the vulcanized plate. The gold lining, extra thin rubbers, and all other materials used in this process can be obtained from dental dèpôts.

Dr. Joseph Speyer has introduced a method of lining vulcanite and celluloid dentures consisting of a thin metallic plate of the thickness of No. 120 foil, the surface of which is covered with minute papilliform prominences (Fig. 507), which are claimed to effect very strong surface

adhesion, while they cause no irritation and leave no marked indentations on the tissues. Fig. 508 shows the prominences magnified four diameters.

New Rubber Facings.—Two comparatively new kinds of rubber have been introduced within a few years that commend themselves for use in the combination plate described above. One is the "granular-gum" rubber facing by Dr. Gilbert Walker, in the use of which the following directions are given: "In waxing up a case, carefully model the gum portions to the exact contour desired, and make the festoons smooth at the necks of the teeth. After flasking, face with a layer of granular gum cut to lie close around the labial and buccal necks of the teeth, and pack against the outer wall of the plaster investment, so that the facing shall not extend above the edges of the plaster. Lap the pieces of granular gum carefully, so that the red rubber will not be squeezed between them, and show on the facing after vulcanizing. In

Fig. 509



Granular-gum faced vulcanite dentures.

packing the red rubber care must be taken not to have an excess, else the overflow may carry with it the granular gum and elongate its colored particles, thus interfering with the mosaic appearance on which the imitation of the gum depends.

The lingual part of the plate may likewise be faced, with care in lapping the pieces of granular gum and avoiding an overplus of red rubber. With this form of rubber, exposure to sunlight for the purpose of developing its color is unnecessary; when well polished the moisture of the mouth will improve the tint.

Granular gum vulcanizes with any of the ordinary rubbers; better results are, however, obtained by vulcanizing it at a low temperature. In finishing, care should be exercised to avoid cutting through the thin facing."

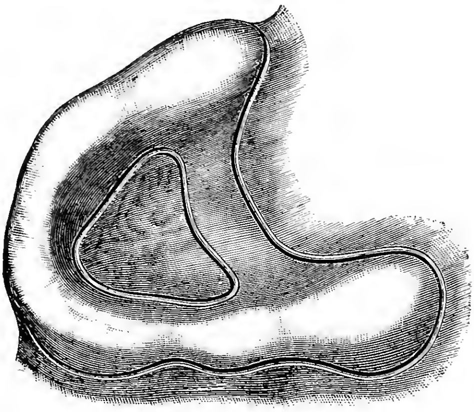
Gear's shaded pink rubber is somewhat similar to the granular gum described above. It may be used in the same manner as the latter, and adds greatly to the beauty and natural appearance of the gum portion of the denture if the preliminary modelling has been done with taste and skill.

Beaded or Grooved Vulcanite Dentures.—For the more complete exclusion of air and moisture between the artificial denture and the mucous

membrane upon which it rests, a groove is cut in the plaster cast as shown in Fig. 510,[1] so that the vulcanized denture should have an integral half-round smooth bead formed on its maxillary surface. The groove must be carried continuously across the palatal portion of the plaster cast and along the buccal and labial lines of muscle attachments, to form a bead-enclosure which should produce a supplemental chamber-like function of the entire inner surface of the denture. (Fig. 510.)

The groove may be conveniently scraped on the plaster cast by one of the larger-sized Palmer's excavators, which, being rounded at its cutting edge, will afford a half-round bead in the vulcanized piece.

FIG. 510



Grooved plaster cast.

Weighted Vulcanite Dentures and Dentures with Contours.—As a rule, lower dentures formed of vulcanite have not sufficient weight to overcome the resistance of the muscles of the cheeks and the sublingual integuments, and when the bite is unusually short they are also deficient in strength, so that breakage of lower dentures is a common occurrence. Both of these defects may be remedied by constructing a platinum or gold plate of two thicknesses of No. 29, soldering suitable anchorages near the top of the ridge in a position which will not interfere with the teeth, and vulcanize as described under the heading of Combination Dentures.

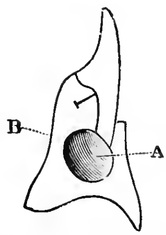
A less expensive method of adding weight to a vulcanite denture consists in using rubber, which is prepared for the purpose with tin filings incorporated with it. By this means the requirements as to weight are very nearly fulfilled, but no additional strength is acquired, the only means of overcoming that difficulty being the use of a metallic plate.

When the bite is unusually long it may be waxed and flasked in the usual manner and after the flask has been separated preparatory to packing, a cylindrical rod of wax may be laid upon the under side

[1] Dental Cosmos of July, 1895, p. 55.

of the blocks or single teeth, as the case may be, of sufficient length to extend from one second molar to the other. The wax rod is then carefully lifted from its place and invested in plaster to form a mold which should be in two equal halves, the line of division being exactly in the centre of the diameter of the wax rod. This mold should have a gate bored through the top for convenience in pouring the melted tin, while at the other extremity it should be provided with a vent to allow the escape of air at the instant of pouring the melted tin. The tin may be melted in a small iron ladle with a suitable handle, and the melting may easily be accomplished over a gas-jet or alcohol flame. When the casting is complete and the tin sufficiently cool, the mold may be opened and the tin facsimile of the wax rod placed in position in the flask, resting upon the teeth, as previously indicated in the description of the preparation of the wax pattern rod. The tin rod should be so arranged that all parts of it will be covered by the vulcanite. Fig. 511 shows the arrangement as described, *A* indicating the tin, *B* the vulcanite. This method possesses the additional advantage of preventing porosity of the vulcanite—an accident which is very liable to occur in bulky lower dentures.

FIG. 511

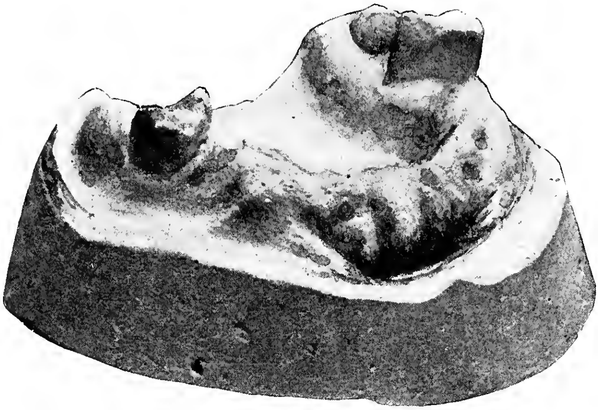


Molded tin weighted vulcanite.

It is sometimes necessary to amplify the denture at points where unnatural depression occurs in consequence of great resorption following the loss of canines or molars. If the amount of projection required to restore natural expression is not extraordinary, slight additions to the rim and the usual vulcanizing may be relied upon to accomplish the desired result; but if the case require a large mass, exceeding a quarter of an inch in thickness, the vulcanizing must be done at a lower temperature, of, say, 300° F., and three hours' exposure in the vulcanizer, in order to avoid porosity. Equally good results may also be attained by forming a core of some light material, enveloping it in rubber, and filling with it the recess in the flask representing the "contour." For this purpose cores of thin metal hermetically sealed, approximating the form of the contour and one-eighth of an inch smaller than the latter may be used. The preparation of metallic forms is, however, a matter requiring considerable labor and time. A much simpler and equally effective method is to form a core either of vulcanized rubber, sponge, or cotton wool tightly rolled and wrapped with thread. In packing the

core is not to be placed in position until the case has been packed and the flask completely brought together, when it may be opened, the recesses representing the contours freed from rubber, and the cores, previously wrapped with strips of soft rubber to the thickness of an eighth of an inch, put in its place. The object of first packing and closing the flask is to prevent the flow of rubber from displacing the cores and to

FIG. 512



Cast of mouth with opening into nasal cavity.

ensure their complete envelopment. In finishing such a case, care must be exercised to avoid cutting through the rubber or exposing the sponge or cotton when those materials are used. Probably of the materials named a piece of hard vulcanite affords the best results and is less likely to lead to failure through displacement, which is always liable to occur.

FIG. 513

Denture constructed for case shown in Fig 512.

The same course as outlined above in the preparation of ordinary contours may be pursued in making plates to restore contours when large portions of the maxillary bones have been lost by disease or accident, such as gunshot wounds, etc. Fig. 512 shows a cast of the mouth in which the whole anterior portion of the alveolar ridge had been removed, leaving a large opening into the nasal cavity, by which speech was seriously affected. After obtaining the cast a thin plate

of wax was prepared to cover the palatal portion extending around the teeth in the form of half clasps, and through the opening even with the floor of the nasal cavity. Upon the wax plate thus prepared the artificial teeth were arranged, and the waxing and flasking done in the usual way. To prevent porosity of that part of the vulcanite appliance which extended into the opening, two or three drops of water were introduced, so as to keep the bulb hollow and in a state of expansion during the vulcanizing process. This water may be removed after vulcanizing by drilling into the bulb and then securely plugging the holes thus made with platinum wire tightly screwed in. Fig 513 affords a sectional view of the appliance.

Spiral Springs.—Vulcanite dentures are occasionally retained *in situ* by means of spiral springs. This method of retention, is, however, but seldom resorted to, except in cases of extreme flatness of the mouth or else in the correction of oral deformities. (For a description of the preparation and adjustment of spiral springs the reader is referred to Chapter XIV.)

Vulcanite Plates and Flexible Rubber Rims.—The use of flexible rubbers in connection with artificial dentures is of doubtful value, on account of the inevitable loss of flexibility of all semi-vulcanizable rubbers when worn in the mouth.

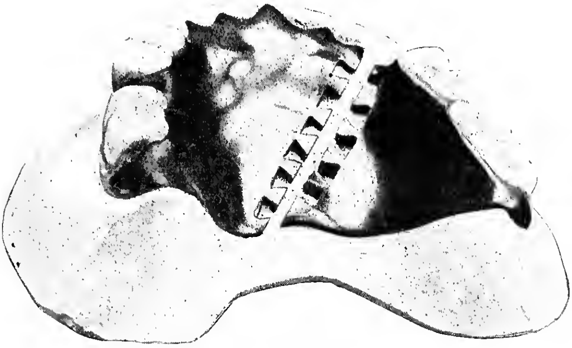
REPAIRING VULCANITE PLATES.

The breaking of vulcanite dentures is usually due to over-vulcanizing, by which elasticity and toughness are destroyed; to improper arrangement of the molars, by which the strain of mastication is thrown on the outside instead of on top of the ridge; or to a warped plate. The first evidence of the giving away of a piece is usually a fine crack appearing between the two central incisors, and sometimes, in partial dentures, in the border surrounding a natural tooth.

Wax Method.—A method particularly applicable to plates which are broken entirely in two, consists in adjusting the two parts of the plate together, and fastening them in correct relation to each other temporarily by adhesive wax dropped on the lingual surface until plaster can be run into the maxillary portion of the denture. As soon as the plaster hardens, the plate is removed from the cast, the line of division is enlarged with a file, and dovetails cut opposite each other with a jeweler's saw, as shown by Fig. 514. The dovetailed space is then filled with wax, invested in the usual way in a flask, packed, and vulcanized. This method is open to one serious objection;—it necessitates another vulcanizing and the consequent loss of elasticity and toughness. A plate so treated will never be as strong as it was before. By another method the edges may be adjusted as before described, and the piece be placed immediately in the lower half of the flask. After the plaster has set, the adhesive wax is to be removed from the lingual side of the plate and a line cut with a round engine bur along the

full extent of the crack, or break, halfway through the plate and a quarter of an inch wide, with smooth, regular edges, without dovetails. The case is then waxed up and the other half of the flask poured—

Fig. 514

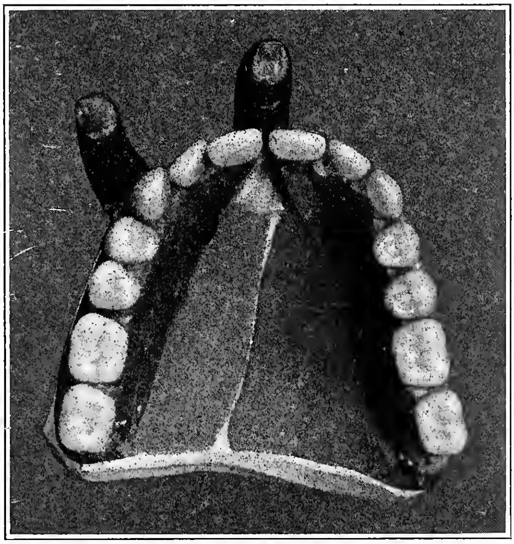


Fractured vulcanite plate dovetailed for repair.

when the case is packed and vulcanized. If the parts have been kept perfectly clean the union will be quite strong.

Another modification[1], which gives the best results is this. After

Fig. 515



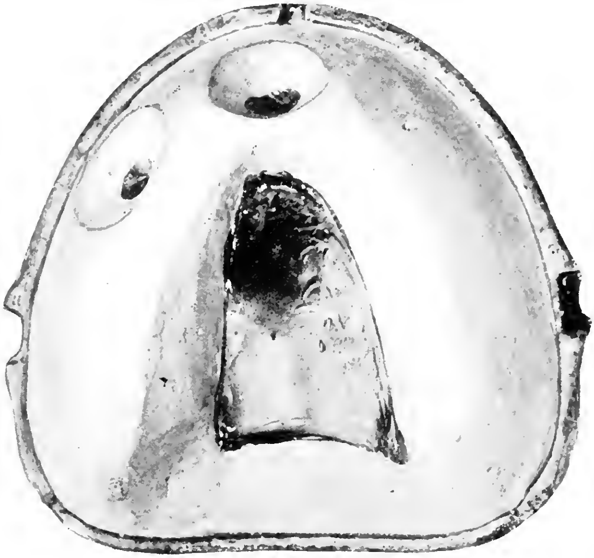
Fractured vulcanite plate prepared for repairing with beveled surface and wax shafts.

the cast is made, the portions of the plate are removed from the cast and with file and scraper a long bevel is cut, forming a thin feathery edge along the fractured edge and sloping away from this for an

[1] The method preferred by the writer.

eighth to one-half inch as the case will permit. (Fig. 515.) The pieces are then filed to give a slight bevel upon the maxillary surface. The portions of the plate which have been cut away are replaced with wax, and if necessary the plate may be thickened over the portion having the freshly cut surface. It is unnecessary to coat the vulcanite surface with a solution of rubber as the heat and pressure will make the union. Fig. 516 shows method of flasking. For description of wax shafts, see page 499.

FIG. 516



Fractured vulcanite plate shown in Fig. 515 invested.

Fusible Metal Method.—To avoid loss of strength by the second vulcanizing it is recommended that fusible metal, melting at 150° or 160° F., be used to fill the dovetailed space. This can be done by pouring the melted alloy into the space and packing it with a hot spatula, which is readily admissible owing to the low fusing-point of the metal. While the method has the advantage of not requiring a second vulcanizing, the union of the metal at the point of fracture is not as close as when rubber is used, and it cannot be said to be reliable as a means of repairing broken vulcanite plates.

A single tooth may be fastened to the vulcanite by filing the dovetailed space as for repairing with rubber, the fusible metal to be put in place with a hot spatula; or the dovetail can be filled with amalgam.

Replacing Vulcanite Method.—Much the better way is to fasten the parts together, run a plaster cast into the denture, then make a bite of plaster to serve as a guide for the replacement of the teeth, remove the latter from the broken plate, reset them to the cast, wax up the piece, flask, and vulcanize. This affords practically a new case, and the time consumed is not much greater than is required in repairing the old one.

Additions to Old Plates.—Additions of teeth to old plates are accomplished after practically the same methods. Fig. 517 shows a case where six teeth have been extracted, and the old plate is prepared for the addition of as many porcelain teeth, so that the denture could be worn until the resorption of the alveoli and gums would admit of the construction of a permanent plate. The illustration shows the plate bevelled off to a smooth edge, and several holes drilled into the filed portion. The correct occlusion of the new teeth is obtained by placing the plate

Fig. 517

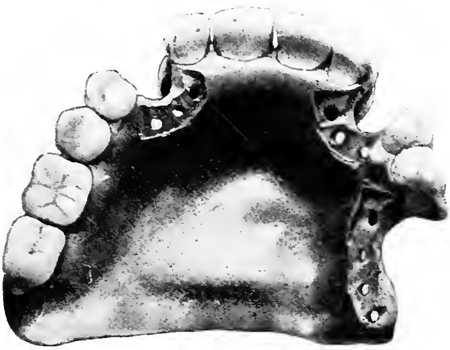


Plate prepared for the addition of several teeth.

in the mouth after the bleeding ceases, placing two pieces of softened wax along the alveolar ridge and plate, and directing the patient to bite into the wax, and then gently pressing the wax while the teeth are in contact. This gives the correct relation of the lower to the upper teeth, and the impression of that portion of the alveolar ridge to be covered by the addition to the plate. The preparation of the plaster cast and bite is done in the usual way, plain teeth being ground to the gums to allow for the rapid resorption which always follows the extraction of teeth. The waxing and flasking are done in the usual way.

Ironing-in Method.—This method is suitable for replacing a tooth or two, or filling a short crack or a hole. The vulcanite is cut with a file to give a dovetailed form to the space into which a tooth is to be added; and a crack or hole should be prepared for the new rubber with a scraper. The new rubber is ironed into place by using a hot wax spatula and firm pressure. Waxable rubber is better for this work than ordinary rubber.

INTERDENTAL SPLINTS.

Interdental splints in conjunction with submental compresses and occipito-mental bandages have been used by surgeons in the treatment of fractured jaws since 1780.

Drs. F. B. Gunning of New York and J. B. Bean of Atlanta, Georgia,

were the first to describe methods of constructing interdental splints of vulcanized rubber. Both of these gentlemen claimed priority, and it appears that the invention was made and published independently by each at about the same period.

The interdental splints of Drs. Gunning and Bean were similar, except that the arrangement of the submental compress and bandage of Dr. Bean differed materially from that used by Dr. Gunning.

Fig. 518

Gunning interdental splint.

Fig. 519

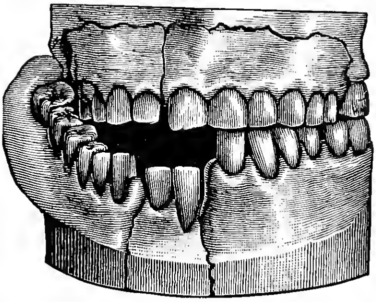
Mental compress.

The Gunning splint (Fig. 518) covered both the upper and lower teeth, and was provided with an opening in front for the reception of food, a bandage over the head being used as a means of securing adjustment of the lower jaw with the splint. Other splints were used by Dr. Gunning which covered the lower teeth only, leaving the motions of the jaw free. Fig. 519 shows the arrangement of the mental compress and bandages employed by Dr. Bean to maintain the relation of the jaws.

The preliminary steps in the treatment of fractures of the jaw are generally made more or less difficult by the pain and swelling incident to the injury. For the impression, plaster-of-Paris is by far the most suitable material, as it necessitates less bulk and may be applied with much less force than is required to press wax or modelling compound to complete contact with the teeth. If plaster-of-Paris be intelligently and skilfully employed in these cases, no violence need be used either in its application or removal. An impression tray of the proper size, with a smooth and polished surface, should be selected and oiled to ensure its easy separation from the plaster when hard. The latter should be of the finely-ground variety, such as is furnished by the dental dépôts for impression purposes, and which hardens quickly, breaks with a sharp fracture, and requires but little force in its removal.

The tray, filled sufficiently with plaster, is applied while the latter is still quite soft, and held until it sets. The tray is then separated from the plaster with scarcely any force; the plaster impression is gently removed in pieces from around the teeth, and the pieces placed in their proper relation to each other in the tray. If any of the teeth have been loosened by the injury to the jaw, the use of plaster of Paris is especially

Fig. 520

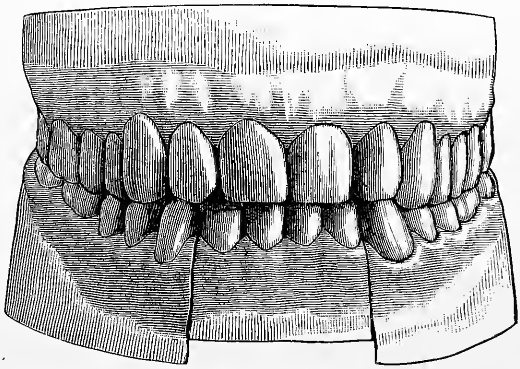


Casts of fractured jaw.

indicated in order to avoid their displacement by the downward pressure of wax or modelling compound.

If the fracture be of a complicated nature and accompanied with considerable displacement of the parts, as shown in Fig, 520, no persistent effort need be made to restore the deranged fragments, as that part of the operation can be just as well accomplished on the plaster cast, the

Fig. 521



The casts cut and the plaster teeth placed in their natural position.

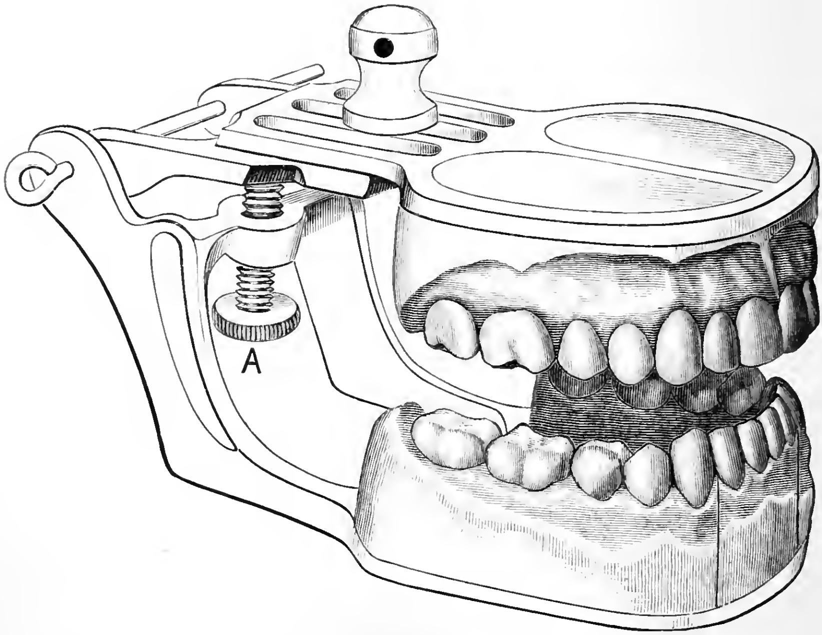
patient being thus relieved from the additional suffering which would be sure to attend any attempt to set the broken parts of the jaw.

An impression is then taken of the upper teeth, the positions of which even when the superior maxilla is broken, are not likely to be changed. When the casts have been obtained cuts may be made with a fine saw through the cast of the lower jaw at points corresponding with the frac-

tures, and the articulation corrected by adjustment to the upper teeth (Fig. 521), which will serve the operator as infallible guides. The parts of the lower cast are then secured in their corrected relation by additional plaster: no effort need be made to set the jaw after the impression is taken until the splint is ready for adjustment.

To preserve the proper relation of the lower to the upper teeth, the cast should be placed in an articulator. (Fig. 522.)

Fig. 522



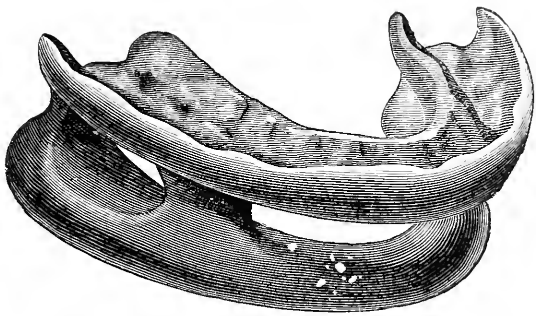
Corrected casts upon the articulator.

The set screw of the articulator should be arranged so as to allow for a separation between the upper and lower teeth of about a quarter of an inch. While it is desirable that the splint when finished should fit the teeth and gums with sufficient closeness to enable it to serve the purpose for which it is designed, it must be borne in mind that to save the patient from additional pain in its adjustment, it is necessary that the fixture should go immediately to its place, without delay or repeated trials. To accomplish this, the plaster teeth and gums for about a quarter of an inch above the necks should be carefully covered with No. 60 tin-foil, for the purpose of slightly enlarging the splint and to secure a smooth surface to the inside of it. Interdental dovetailed space may be arranged by filling the undercuts with plaster before applying the foil, or by trimming away retaining points in the finished piece with a sharp knife-blade or engine bur, so that the splint may be applied or removed without much force. The splints are then formed on the plaster

casts of thin sheet wax of a uniform thickness slightly in excess of a sixteenth of an inch; wax of a sufficient thickness is then placed between for the purpose of uniting them, as shown by Fig. 523.

The upper and lower splints are to be carefully united and made perfectly smooth by means of a hot spatula.

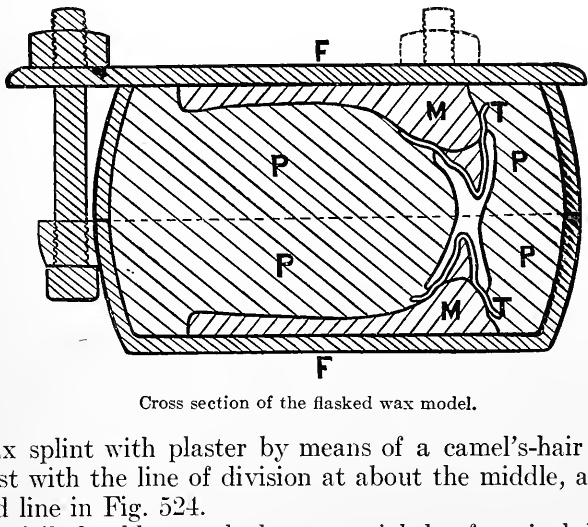
Fig. 523



Wax model for interdental splint.

The wax splint is next to be removed from the cast and invested in a suitable flask in the usual way. The casts may be removed from the articulator for the purpose of vulcanizing upon them; this, however, is not really necessary. It is, indeed, a better plan to preserve the casts and articulation to assist in the preparation of the finished splint for final adjustment. A much better way is to carefully fill the deep parts

Fig. 524



Cross section of the flasked wax model.

of the wax splint with plaster by means of a camel's-hair brush, and then invest with the line of division at about the middle, as shown by the dotted line in Fig. 524.

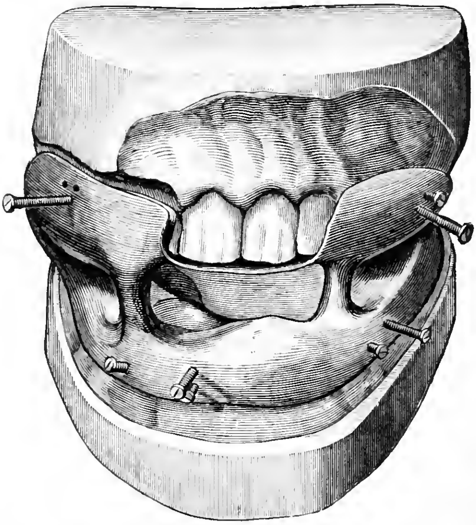
The tin-foil should extend about an eighth of an inch beyond the wax; it will thus be held securely by the investment, and disarrange-

ment when the flask is separated for the removal of the wax will be avoided.

A sectional view of the flask with the encased splint is given in Fig. 524. The flask is shown by *F;* the casts by *M;* the plaster encasement by *P;* tin-foil covering the teeth with extension beyond the wax splint by *T;* the wax pattern of splint in the centre.

The same precautions recommended for the waxing, flasking, and packing of ordinary vulcanite dentures should be observed in the construction of splints, but especial care should be observed in the separation of the flask to avoid breaking the thin plaster teeth, as such an accident would greatly embarrass the subsequent steps of the operation.

Fig. 525



Kingsley's splint.

The flask should, therefore, previous to any attempt to separate it, be placed in hot water, and allowed to remain until the wax is quite soft. After the separation the last particle of wax should be washed away by means of a stream of boiling water.

The packing of the rubber demands more than ordinary care to ensure its being carried into the deep and narrow spaces around the teeth. The rubber should be cut into thin strips, softened over boiling water, and carried into the matrix by a suitable instrument, such as an old plugger. There should of course, be a slight excess of rubber. The vents may be as for ordinary dentures.

Interdental splints need not be thicker than is consistent with sufficient strength. They should be well finished, and provided, when admissible, with a front opening, as shown in Fig. 523, large enough for the passage of a feeding-tube.

An interdental splint cannot usually be relied upon to immovably retain the broken jaw without the assistance of bandages, screws, wires,

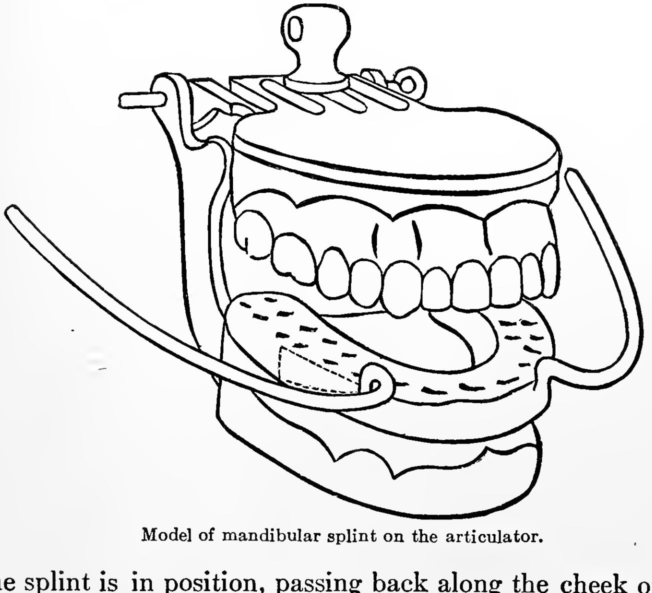
or ligatures. Fig. 525 (Kingsley's *Oral Deformities*) shows the use of screws passed through the splint at points between the cervical portions of the crowns of the molar teeth.

Fig. 526 (*ibid.*) illustrates a splint provided with arms of steel wire one-eighth of an inch in diameter, arranged to come "out of the mouth

Fig. 526

A dental splint for the mandible in position.

Fig. 527



Model of mandibular splint on the articulator.

when the splint is in position, passing back along the cheek on a line with the teeth." This splint was invented by Dr. Norman W. Kingsley, and the description of it, with the illustration, is from his valuable

work on *Oral Deformities*. Fig. 526 shows the splint in position and the submental compress attached to the side-bars.

It will be seen that this splint covers the lower teeth only, and that its top occludes with the upper teeth to admit of mastication. The construction of such a splint is accomplished by placing upper and lower casts in an articulator, forming the wax splint as before described, arranging the occlusion so that contact of the upper teeth will be uniform, imbedding two stout steel wires with flattened ends in the wax, so that they will bear the strain which will be required of them while the splint is in position. Fig. 527 shows the waxed splint with side-bars in the articulator ready for investment. The particular flask best adapted for the vulcanizing of interdental splints is oblong in form, and is larger than ordinary vulcanite flasks; it is known as the "box flask."

CHAPTER XIV.

SWAGED METALLIC PLATES.

By William H. Trueman, D. D. S.

The sheet metals employed as bases of support for artificial teeth are gold, silver, platinum, and aluminum.

Platinum is rarely used as a base-plate for soldered dentures; it is too soft; its relative infusibilty, however, fits it for employment when covered by substances fusing at a high temperature, as when faced with porcelain in continuous-gum dentures. An alloy of platinum and iridium, known as iridio-platinum, is occasionally employed in making plates, the addition of iridium producing a very rigid alloy. It is difficult to work, and more expensive than gold. It is said to withstand the oral secretions better than gold alloys. The slight advantage it may have in this respect is over-balanced by its objectionable color and excessive weight.

Aluminum is occasionally employed as a base-plate, the denture proper being mounted in vulcanite. Its lightness and comparatively easy working properties recommend it; the impracticability of neatly and effectively soldering it very much impairs its usefulness in dental prosthesis.

Sheet gold for making plates is usually eighteen carats fine, that is, each pennyweight contains eighteen grains of pure gold and six of alloy. This has long been accepted as a standard. It is sufficiently fine to withstand the corroding tendencies of the oral fluids, and sufficiently rigid for strength, if the alloy contains a portion of either copper or platinum. Gold, silver, and platinum, when pure, are very soft and pliable, and alloys of gold and silver, or gold and platinum, in which the gold greatly predominates differ but little in this respect from the pure metals. Pure copper is a little less soft, yet a small portion confers upon the alloy a remarkable rigidity. An alloy of gold twenty-one parts to three parts of platinum, while showing the presence of platinum by a marked change in color, is almost as soft and pliable as either of its components; the addition of a small portion of copper, or of copper and silver, makes an alloy as elastic and rigid as tempered steel; it is indeed, the alloy known in dental prosthesis as platinous or clasp gold, used on acount of its strength and elasticity to re-enforce weak areas in plates made of more pliable alloys, and for clasps and springs.

It is advisable, and will save much trouble in utilizing gold scraps and filings, to limit the varieties of gold plate and solder used in dental plate work, and to select and use exclusively a few standard formulas judiciously chosen. For plates, eighteen carat is commonly used; a lower grade than eighteen is inadmissible, and

a higher grade is rarely required on other than æsthetic grounds. As twenty-two carat, or where rigidity is required, coin gold have become generally accepted standards for crown-and bridge-work, simplicity will be consulted by accepting either of these as the higher grade for plate work. The choice of alloying metals is limited to silver, copper, and platinum. Silver merely cheapens the metal; beyond changing its color, it alters its physical properties so little that foil of a silver and gold alloy twenty carats fine has been successfully used, experimentally, for filling teeth. Silver alone not only fails to impart a desirable rigidity, but it imparts an objectionable "brassy" appearance, and the alloy does not take the polish and pleasing color associated with gold. Copper, when used alone imparts rigidity in too great a degree; it also gives to the alloy a reddish hue. While the alloy takes a high polish, and has a rich color, it soon tarnishes in the mouth and assumes an objectionable copper color. The two metals combined in proper proportions impart to the alloy a desirable strength and color. The purity of the metals in the alloy is an important consideration. Commercially pure gold and silver are readily obtained from refiners of the precious metals, and should always be used instead of coin in making gold plate. The generally accepted idea that coin is a reliable source of the precious metals is an error. The mint standard is fixed only as regards the product as a medium of commercial exchange; this, and the wearing properties of the coin are alone considered. The pure metals are more reliable, and are no more costly. Commercial copper is an unknown quantity; it and its various alloys, should be rigidly excluded, and chemically pure copper obtained from dealers in fine chemicals, prepared expressly for chemical usage, used in its stead. While the difference in cost is very great, the small amount used makes the item insignificant.

The following formulas will meet all requirements of dental plate work:

Gold Plate 18 Carats Fine.

Pure gold	18 parts,
Pure silver	4 "
Pure Copper	2 "

Gold Plate 22 Carats Fine.

Pure gold	22 parts,
Pure Silver	1 "
Pure Copper	1 "

If greater rigidity is desired, from one-half part to one part of silver may be replaced with platinum in either formula.

Gold Plate for Clasps, 18 Carats Fine

Pure Gold	18 parts
Pure Silver	2 "
Pure Copper	2 "
Platinum	2 "

The alloy for clasps may be used for clasps on either eighteen or twenty-two carat plates, the fusing point is sufficiently high to permit the use of twenty-two carat solder, and the difference in color between

this and a higher carat containing sufficient platinum to impart the required elasticity is not objectionable. It may also be used with advantage for making the backings for all eighteen carat gold dentures on account of its greater strength, and for reinforcing partial dentures for either the upper or the lower jaw.

Silver plate is the 900-fine alloy of silver and copper known as coin silver. Pure silver is too soft and inelastic used alone. Since the advent of vulcanite it is now seldom used.[1] While in most mouths it is quickly discolored, and in a few exceptional cases is corroded and dissolved, it serves a good purpose when a metallic plate is required and the expense of gold is objectionable. Coin silver plate is not quite as rigid as eighteen carat gold, and, therefore, must be made considerably thicker. It is somewhat easier to work than gold, but requires more care to avoid overheating in annealing and soldering, and it is well to remember that it is readily and quickly dissolved in boiling sulphuric acid. The dilute acid used as "pickle," is frequently heated to expedite the process of cleansing a case after soldering. It is quite safe, provided the acid is not too strong, and the boiling is not continued too long. When this "pickle" is boiled, the water is evaporated more rapidly than the acid, and a time comes when it reaches a concentration that dissolves silver as quickly as does its proper solvent, nitric acid. It is a wise precaution, therefore, to allow the silver to remain in the acid solution only sufficiently long to accomplish the cleansing.

A suitable alloy for silver plates is made by adding to pure silver one-tenth its weight of pure copper. Attempts have been made to improve this alloy by adding platinum or iridium. If these costly metals are added in sufficient quantity to materially increase the strength or durability of the alloy, it becomes as expensive as gold, while far inferior to gold as a base for an artificial denture.

Alloys of gold and of silver, containing a small portion of zinc to reduce the fusing point, are used as solders to unite the various parts of a finished denture. It is commonly asserted that zinc makes with gold a brittle alloy; this is true only of the impure commercial zinc, and is due in all probability to some impurity it contains rather than to the metal itself. Chemically pure zinc may be added to alloys of gold and of silver in sufficient amount to produce freely flowing solders without impairing materially their ductility, while a few grains of filings from a zinc die are at times quite sufficient to make an ingot of gold weighing several ounces so brittle as to break like a piece of crockery when struck with a hammer. The only grade of zinc admissible for making gold and silver solders is that known as "strictly chemically pure." All formulas calling for brass, spelter, or other zinc and copper alloys should be discarded, these alloys are of uncertain composition, and in addition contain many injurious impurities. The following formulas are sufficient:—

[1] The writer has recently met with a case where a vulcanite plate could not be worn on account of its irritating the surface with which it was in contact. Two gold plates were made, differing in size and mode of support, which proved quite as uncomfortable. A silver plate was next tried, and proved quite satisfactory, and is worn with comfort.

Eighteen Carat Gold Solder.

Pure Gold	18	parts
Pure Silver	3	"
Pure Copper	2	"
Pure Zinc	1½	"

Twenty-two Carat Gold Solder.

Pure Gold	22	parts,
Pure Copper	1	part.
Pure Zinc	1½	parts.

Silver Solder.

Pure Silver	19	parts,
Pure Copper	1	part.
Pure Zinc [1]	4	parts.

Some little care and dexterity are required to get into the alloy the full amount of zinc. Zinc is not only readily oxidized at the temperature at which the noble metals melt, but it is also volatilized. No flux will prevent this. The noble metals are first brought to full fusion, the crucible containing them is taken from the furnace, the zinc dropped in, and after a quick dexterous shake, its contents are immediately poured into the ingot. Before rolling the ingot it may be tested by breaking off a small portion from a corner. The eighteen carat gold solder should flow freely upon a piece of silver plate of about 26 gauge; the twenty-two carat may be tested in like manner upon a piece of eighteen carat plate; and the silver solder should freely flow upon silver plate. Solders made from the above formulas will do this if properly made. There is no necessity for, and no advantage in using solders of a lower carat than the plate for new work. There is ample margin between the fusing point of the above solders and the same carat plate to permit their safe use with ordinary care. A sixteen carat gold solder may at times be needed for repair work, for other purposes it should have no place in a dental laboratory. Solders should be rolled to about No. 28 (Brown and Sharp gauge).

In manipulating gold and silver, they must be frequently annealed by being heated to a dull red heat and plunged into cold water. Under manipulation they soon become inelastic and obdurate, and must be reannealed as soon as this condition is re-established. There is no advantage in annealing at a very high heat, but on the contrary, there is serious risk of overheating, especially with silver. If either metal is allowed to become so hot as to be fused upon the surface, it is not only roughened, but the texture of the metal is in a measure destroyed.[2]

Particles of base metal must be kept from the surface of gold or silver; a particle of lead, tin, or zinc will, when heated, form with the metal underlying it a brittle alloy melting at a low temperature, so that when the plate is again heated a hole is burned through at that point. The hard rubbing which necessarily occurs between the dies and the plate

[1] Notwithstanding the large proportion of zinc—if the zinc is pure—this solder is free from brittleness and keeps its color in the mouth.

[2] It is possible to produce blisters on sterling silver by overheating it during annealing in an oxidizing atmosphere. It is generally assumed that blisters are a fault in the metal itself, and are caused by imperfect melting. Experiments show that sterling silver cannot be blistered when a reducing flame is used in annealing, but an oxidizing flame produces numerous blisters, due to the silver absorbing oxygen when the temperature approaches the melting-point.

during the process of swaging imparts to the plate a thin film of base metal; if this is permitted to remain when the plate is annealed, while it may not be in sufficient amount to immediately cause a hole, it may so impair the texture of the metal that later a hole suddenly appears either from rupture or fusion. To avoid this the plate should be "pickled," that is placed into a bath of sulphuric acid and water to remove any particles of base metal immediately before annealing. This should be done before it is annealed every time the plate is swaged, or brought in contact with the metal dies. The "pickle" acts more promptly and certainly if it is heated to near its boiling point; otherwise a few minutes must be allowed for the acid bath to do its work. Careful attention to these little matters will save a great deal of trouble and annoyance at a later stage of the work.

FORMING THE PATTERN.

The first step in constructing a plate is the important detail of making a pattern to serve as a guide in cutting to the required dimensions the metal of which the plate is to be made. This may seem a simple and unimportant matter, but a little experience will prove that this is not the case. Apart from economy in working with the precious metals, having the form from which the plate is to be made of exact size and shape, especially for partial and full lower plates, is not only a saving of time but enables the workman to produce a better result than when cut to a faulty pattern, for then the metal must be strained, and often torn, in adapting it to the dies. It should be made exactly to the lines drawn on the cast to indicate the extent of the plate. This pattern may be made of thin sheet lead, or heavy tin-foil, or a rather soft paper, such as is used for newspapers, for instance. If lead or tin is used, the pattern should be formed on the die to avoid bruising the plaster model. The pattern metal is laid upon the die, and by the fingers is pressed into the deeper portions of the die; the rubber tip of a lead-pencil, a wad of soft paper, or a burnisher is then used to secure a closer adaptation. When the pattern has been made to conform to the die, it is removed to the model and accurately trimmed to the plate lines. If paper is used, all the work may be safely done upon the model. The writer much prefers to make the pattern of paper. With care, a paper pattern can be made sufficiently accurate for all practical purposes. While patterns of tin or lead can be more readily made to conform to the model, they are much more difficult to flatten out without distortion, especially in those cases where distortion causes the most trouble. In upper plates, either partial or full, there is but little trouble in securing sufficiently accurate results. Where the palatal vault is high, it is necessary to press the pattern well into it, or it will prove too small at the sides. In lower cases, partial or full, it is very important that the pattern should give the proper curve as well as the dimensions of the plate, especially so in cases such as that represented by Figs. 528 and 529. At best, such plates are difficult to make, and any inaccuracy in the curve of the pattern will give a great deal of additional trouble. The usual

tendency is to make the pattern too straight—not curved enough—owing to the pattern not being properly adapted at its lingual aspect when the sides are trimmed, or to its being stretched out of shape when it is flattened out. Figs. 530 and 531 will give a general idea of the form such a pattern should have for the plate represented in Figs. 528 and 529. Patterns for any additional pieces of metal that may be needed to complete, the plate should be made at the same time. If for an upper plate with a soldered chamber, a pattern for this will be required, about one-eighth inch larger on all sides than the base of the chamber. Occasionally it is best to extend the back margin of the chamber-piece to the margin of the plate, or if the distance from tuberosity to tuberosity is excessive, this covering piece may be extended at the angles, forming buttresses to the plate, as shown by dotted lines in Fig. 532. If the plate is to be double, both pieces of metal may be cut by the same pattern. Partial lower plates require a reënforcing piece across the space occupied by the natural teeth, and to about half an inch beyond on each side, and in some cases where the plate at this point is narrow, or the

Fig. 528

Partal lower plate supporting posterior teeth only.

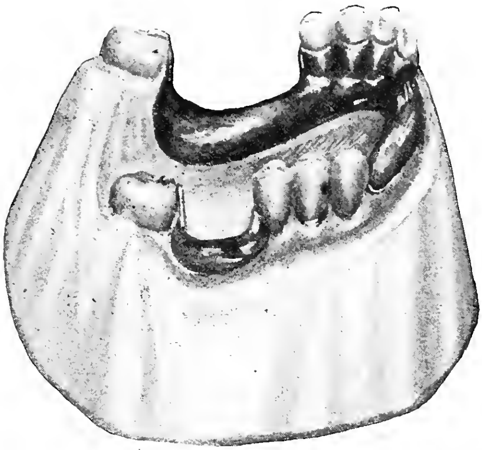
space is long, a third piece, somewhat smaller, preferably made of platinous gold if the plate is of gold, will be required to ensure sufficient strength and stiffness. It is desirable that all the patterns should be made before attempting to cut the metal, as it frequently happens that they can be fitted, the one beside the other, so as to economize the stock from which they are cut.

PREPARING THE METAL FORM.

The thickness of the metal for a dental plate is governed by the size and shape of the intended denture. A very small plate can be safely made thinner than a large one; a vacuum-chamber plate covering a small area of the palate, compact in form and stiffened by its various

corrugations, and by a stamped or soldered vacuum-cavity, may be made much thinner than a narrow clasped plate, horse-shoe in shape. A plate for a flat mouth should be made heavier than one for a deep palatal vault, or for a cast with a sharp prominent ridge. Plates for the lower jaw should be heavier than those for the upper, and a silver plate

Fig. 529

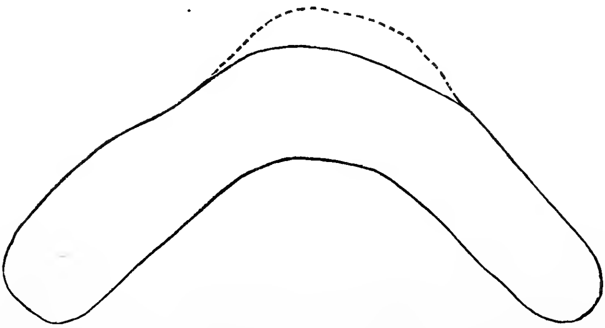


Partial lower plate supporting anterior and posterior teeth.

should be two or three numbers heavier than one of gold for the same position.

Where great rigidity is needed, it is good practice to make two thin plates and solder them together. By this means greater rigidity is obtained than by a single plate of the same weight, and a better adapt-

Fig. 530

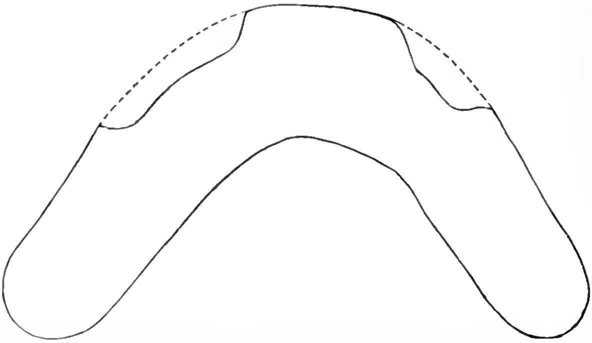


Pattern for a partial lower plate supporting the posterior teeth only, like Fig. 528. The dotted line indicates the extension of the metal form beyond the line of the pattern, to allow for a portion of the metal to be bent or hooked over the front of the die to prevent the plate slipping backward during swaging.

ation is secured, because the thinner metal is more pliable during swaging. For gold the gauge may range for single plates from about No. 24, which is about as thick as can readily be swaged, to about No. 28, while No. 29 or 30 is suitable when two plates are made and soldered together.

Having decided upon the thickness, and having rolled the metal to the required gauge, the patterns are arranged side by side so that they may be cut from it with the least waste. While the patterns should be made accurate, some little allowance must be made when cutting the metal by them for any slight change in position the metal may take during

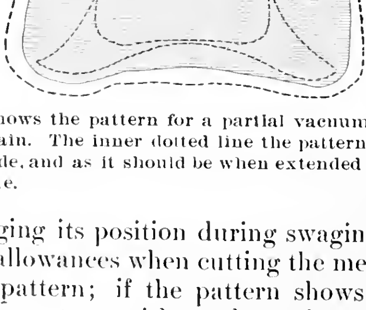
Fig. 531



Pattern for a partial lower plate supporting anterior and posterior teeth, like Fig. 529. The metal form is cut as shown by the dotted lines.

swaging. With all plates an allowance of a full sixteenth of an inch should be made on all sides, as shown by the dotted lines in Fig. 532. The indentations to accomodate remaining natural teeth should not be too closely followed. An allowance should be made in the front portion of forms for plates like Fig. 528, as shown by dotted lines in Fig. 530, to allow for a portion of metal to be bent or hooked over the die and so pre-

Fig. 532



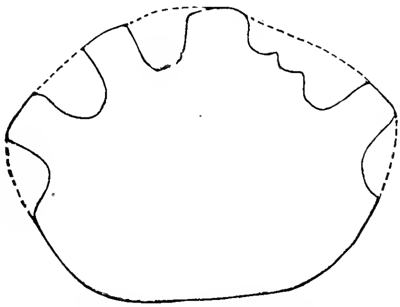
The shaded portion shows the pattern for a partial vacuum plate where the natural canine teeth alone remain. The inner dotted line the pattern for the vacuum-chamber cover as ordinarily made, and as it should be when extended to the tuberosities to give rigidity to wide, flat plate.

vent the plate changing its position during swaging. The writer prefers to make these allowances when cutting the metal form rather than when making the pattern; if the pattern shows the size absolutely needed, by fitting one pattern with another or by reducing the allowance at immaterial points, the plate can be cut more economically. At places

representing the necks of the teeth the plate should always be cut with a rounded, never with an angular outline. The plate is unavoidably subjected to considerable strain during the swaging process; this is apt to start a break or tear at any point of its periphery weakened by a slight cut or angular indentation. A greater surplus is allowed with partial lower plates to compensate for the greater danger of displacement in swaging; as they are very apt to slip to one side or the other, especially at that portion covering the distal portion of the ridge, it is, therefore, wise to make the form a little wider at this point than the pattern calls for. While it is well to remember that gold plate depreciates very much in value when reduced to scraps, it is not wise to cut so closely to the pattern as to risk losing valuable time in accurately adjusting the form within the plate lines, or perhaps spoiling the piece by its slipping to one side beyond recall.

Having laid the pattern upon the metal of which the plate is to be made, selecting a position where it can be cut with the least waste, trace

Fig. 533



Pattern for a partial vacuum plate such as shown by Fig. 526. The metal form is cut as indicated by the dotted line.

its outlines with a sharp point or tracer, and cut to this line with straight or curved shears as may serve best, as closely as may be deemed prudent. In cutting the form for a partial upper plate it is best not to follow the outlines of the pattern where it is cut out to fit around the natural teeth, but to leave these portions to be removed after the plate is partly fitted to the die. If the form is accurately cut to the pattern, it must be accurately adjusted to the die—in practice a very difficult task. Fig. 533 shows the outlines of the pattern—the dotted line the size and shape to which the metal should be cut for a plate like Fig. 534.

In cases requiring an extra rigid plate, or in cases especially difficult to swage, whether to make a heavy single plate or two thin ones and solder them together, is a matter upon which there is a difference of opinion. A plate made of two laminæ thoroughly soldered together, is undoubtedly much more rigid, and is usually heavier than can readily be swaged as a single plate. Apart from this, the slight unevenness in the thickness of the solder, owing to the two plates not being in absolute contact at all points, tends to give it increased rigidity. Partial lower plates must be thus stiffened where they pass behind remaining

natural teeth. Practice differs as to whether a narrow full lower plate, or a narrow upper clasped plate, horse-shoe in shape, should be so made. In the writer's judgment a full lower plate made of a proper thickness with its edges all around bound with half-round wire, will usually be sufficiently rigid for all practical purposes. A narrow upper plate requires to be doubled over the greater part of its area. The writer prefers to make the plate heavy, and to make the strengthening piece from one-eighth to one-fourth of an inch narrower than the plate, so as to leave its free edges of a single thickness. This does not impair its strength or rigidity, while it permits a ready bending up or down of these edges to accommodate those changes taking place in the mouth after the plate has been worn, which require at times that the plate be made to fit closer, and at other times that undue pressure upon the soft tissues be relieved. There are certain points in all partial plates to be in-

Fig. 534

Partial vacuum plate to support several isolated teeth.

dicated later, which are especially liable to fracture, and which require additional strength beyond that necessary to make the plate sufficiently rigid to retain its shape when subject to the wear and tear of actual use. The resistance of the dies limits the thickness of plate that may be used. If to make a plate thoroughly strong, calls for a greater thickness than can be readily and accurately swaged, a double plate is required.

MAKING THE PLATE.

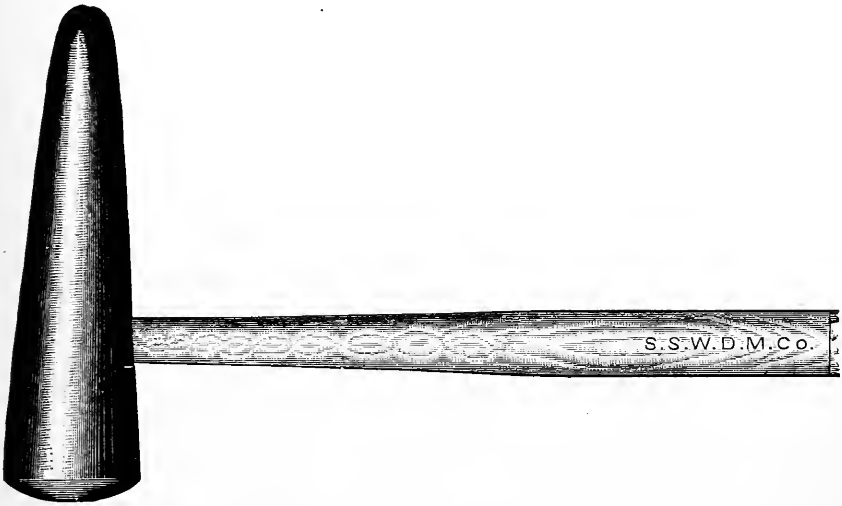
The sheet metal form is annealed by being heated all over to a dull red heat, being careful, however, especially when working with silver, that it is not made so hot as to be "burned" or "sweated;" that is, fused on the surface. When this has been done the plate is not only roughened, but its texture is destroyed, and it becomes in a measure brittle. It is a matter of no moment whether the plate is cooled quickly or slowly

after annealing; it is usually plunged into cold water to save time. It should be annealed every time it is swaged: before doing so it should be placed for a few minutes in a bath of equal parts of sulphuric acid and water, or a boiling solution of alum, technically termed "pickle," to remove any particles of base metal that may have adhered to or become attached to it. If these are allowed to remain, when the plate is heated they become alloyed with it, and either produce a roughness, or a hole, according to the amount present.

There is but little difference between the manipulation of gold and silver in making a plate, except that gold, being stiffer and becoming hard sooner, requires a little more manipulation and more frequent annealing than silver.

Making a Plate for a Full Upper Denture.—The poorer die is cleansed by brushing off any particles of sand or metal; any inaccuracies are cor-

Fig. 535



Horn or wooden mallet, used to adapt the metal form to the die preparatory to swaging.

rected, and any roughness not shown on the model made smooth. Place it upon a portion of the work-bench, where it will rest solidly and firmly, or, better still, hold it in the jaws of a bench vise, the back part toward the workman. Have the plaster model near at hand so that the position and extent of the plate may be seen at a glance. Now place the annealed form on the die, having first smoothed or rounded any sharp points left by the shears that might cut the hands, and note the position in which it will best cover the outlines of the plate. Holding it firmly in position with the left hand, with a horn or wooden mallet (Fig. 535) held in the right, bend down the outer edge with light, rapid blows, being careful that the position of the plate is such that it will extend over the ridge far enough to meet the lines drawn on the cast, and also allow for the sides to be drawn in when the plate is swaged

into the palatal arch. It is not desired at this stage to make the edge fit closely to the die, but simply to give it a downward tendency, so that when the mallet is used to drive the centre down, the tendency of the plate to slide backward will be checked, while the edges being thus bent, will at the same time naturally be drawn closer to the die. If the centre of the plate should be fitted first, the edges will naturally flare up; the effort to bring them into position would not only tend to again straighten the centre of the plate, but also to stretch and throw the outer edge into folds or creases. When once this movement has started, it is very difficult to control; the pounding necessary to work out these folds will, by stretching the plate, increases the difficulty.

It is best, especially in deep mouths, to work the plate well down to the centre of the die with the mallet before using the counter-die. The skilful use of the mallet "draws" the metal into place; it is free to slide over the ridges as it is bent down into the die by the mallet; as soon as the counter-die is used, that portion of the plate over the ridge becomes "set" and does not so readily "draw in" to the concavity of the die. The metal is stretched, and in very deep mouths the plate may be split if the counter-die is used too soon. The mallet should be held lightly between the thumb and fingers, not grasped in the hand, and the blows struck should be light, rapid, and springy; otherwise the plate becomes battered and bruised. Some workmen prefer to fit the plate into the palatal portion of the die by the use of partial counter-dies, that is, counter-dies made to fit into the palatal portion of the die only, and not extending over the ridge. A series of these are required, beginning with one taking in the middle portion of the palate only, each succeeding one extending further toward the ridge. During this process the plate will require frequent annealing, always preceded by a bath in the pickle. After the plate has been fitted as well as it can be with the mallet, place it on the die, first covering the face of the die with several thicknesses of thin paper, cloth, such as comes with vulcanized rubber, or a rubber dam, and placing a like covering of paper over the plate, accurately adjust them to the counter-die. At this early stage of the swaging there is more rubbing between the metal and the dies than later, and this paper not only protects the plate from the base metals of the dies, but saves it from being bruised and roughened. Place the die and counter-die, with the plate between them on the anvil, with the counter-die down, and while grasping the die with the left hand, holding it firmly in place, strike it a light blow with the large hammer. Now examine and make sure that the plate has not moved, as it is apt to do, then holding it as before, strike several moderately heavy blows. It is desired at this stage to simply fix the plate in position. Remove it from the dies, pickle and anneal it. In using the swaging hammer grasp the handle near the head of the hammer, and strike deliberately, firmly holding the hammer down so as to prevent any rebound. If the hammer is allowed to rebound, as it tends to do, the die follows, and in settling down again, is apt to slightly change its position. It requires very few of such blows to produce a plate no one can

make fit the model accurately. The character of the force used in swaging is a matter of great importance, not only in making a plate to fit, but also in making a plate that will not change its fit in subsequent operations. The nearer the hammer blows resemble those of a drop-press, or a pile driver, the more effective they will be. If it were practicable to make dies and counter-dies suitable for it, a screw or hydraulic press would be ideal for swaging dental plates.

Now, examine first if the plate is in a position to well cover all the lines; next note if there are any wrinkles or creases on the palatal portion of the plate. With some forms of palatal vault they are apt to occur at the posterior edge of the plate, and should be promptly straightened with the mallet. Then see that the plate is well down to the die at the central portion of the palate. At times this first swaging tends to draw the plate up, especially so if the counter-die extends too far over the die. If the plate does not fully cover all the lines, its position can be changed at this stage by bending with the mallet. It is important, before proceeding further, to make the palatal portion of the plate fit closely to the die, using the mallet to drive it down if necessary. The portion extending over the ridge next requires attention. First straighten out any wrinkles that may have formed, and make the plate fit as closely as possible the outer portion of the alveolar ridge. To facilitate this, cut off with the shears any surplus portions of the plate that extend to a marked degree over the lines, remembering, however, when so doing, that the tendency of further swaging may be to draw these edges up. In some plates it is necessary to remove a V-shaped section at the frænum before they will lie close along the outer portion of the ridge; it should not be done, however, at this stage. During these manipulations whenever the plate becomes rigid and unyielding, it should be annealed. When the plate has been made to fit well as it can be with the mallet, it is annealed and again swaged between the dies, using paper or cloth on each side as before. After a few light blows, separate the dies sufficiently to see that the plate has not changed in position; if found satisfactory in this respect, it should now receive a thorough swaging, moving the dies around with the left hand and striking heavy blows over successive portions of the die.

Attention is now given to the vacuum-cavity. If it is of the Gilbert pattern, swaged with the plate, two special tools are needed to give it a sharp outline, and to make it fit at its edges close to the roof of the mouth. First is a chaser made of bone. This may be made of a toothbrush handle, one end of which is filed to a moderately sharp, smooth chisel-like edge, rounded at its corners, and about one-fourth of an inch wide. This edge will require frequent renewing, as it is soon battered by use. It is used by placing the edge of the chaser in the imprint of the chamber while the plate is on the zinc die, and holding it at a slight angle as one would a chisel in cutting a groove, striking light rapid blows on the end with a mallet or bench hammer, so as to drive it down and forward. Pass it round the chamber in this way repeatedly, so as to coax the metal into place.

If the blows are struck too hard, the chaser will indent the plate, and the indentations once made, are very difficult to remove. In some cases this bone chaser will complete the vacuum-chamber. If greater sharpness of outline is desired, it is followed by a steel chaser with a thinner, but well rounded smooth edge, polished like a burnisher. This is used in the same manner, but with caution. If used to excess it may cut a groove that must be filled with solder to make a neat finish. This chasing of the vacuum-chamber is only partly finished on the first die; it is completed after the plate has been lightly swaged on the second or finishing die. During the process, the plate must be frequently annealed. If a soldered vacuum-chamber is desired, and the form for the chamber has been cast on the die, the proceedure is somewhat different. An opening is cut in the plate corresponding to the chamber, but not to its full size at this stage. Until the plate has been thoroughly swaged on the second or finishing die there is a possibility of its slightly changing its position, for this reason accurate fitting to plate lines is deferred until that time. Roughly cutting off the surplus plate with the shears, chasing the chamber, or cutting the opening for a soldered chamber, no matter how carefully done, distort the plate to some extent; therefore, all this should be done before commencing to make the plate fit the model accurately. The final fitting to the plate line is readily done with the file without risk of bending the plate, and at the time this is done, the opening for the chamber is enlarged until it exactly coincides with the base of the wax chamber on the cast. A covering piece is then swaged up as sharply as can be done with the dies; it is not necessary to use the chasers. This is then trimmed all round to leave a margin of about one-sixteenth of an inch; if it is desired that this margin should be well defined on the finished plate, the edge is filed square; if on the contrary this is not desired, it is filed from the under side to a feather edge. In some cases the back edge of this covering piece is extended to the plate line, not alone for additional strength, but to increase the thickness at this point to provide for filing from the underside to relieve pressure upon the hard palatal ridge. Again, in a very broad mouth, the covering piece may be extended toward the tuberosities to give stiffness and rigidity to the plate.

Instead of making a wax model of the chamber on the plaster model and reproducing it on the die, a better result is obtained by making the model of the chamber in copper or brass as thick as the chamber is intended to be deep. A piece of copper or brass of proper thickness is fitted by means of the bench hammer into the first die in the position of the desired chamber, held in place by a little adhesive wax, and swaged between the die and counter-die. As this usually changes its position it should be sufficiently large to well cover the lines of the chamber notwithstanding this, so that when it is shaped it will accurately fit the die in the position marked for it on the cast. This is done with the first die and counter-die. It is then made the desired shape and size, and the edges are smoothly finished with a slight bevel. An expert workman has no difficulty in attaching this to the finishing die with adhesive

wax and swaging it into the counter-die so as to produce in the counter-die a depression into which the covering piece is swaged. There is, however, a marked tendency in the chamber model to slide backward or sidewise, to prevent which the writer is accustomed to tack it to the plate, whether of gold or of silver, with the least possible mite of silver solder. It can be readily held in position on the plate with a wire clamp while this is being done. By this expedient all risk of change in position is obviated, and after it has been swaged so as to make an impression in the counter-die, by inserting a point under its edge, and heating the plate, the chamber model is released. The impression made in the counter-die requires deepening by means of flat gravers before swaging the covering piece. This method has the advantage that making the sand mold is not complicated by the presence of the chamber model; it also avoids bending up the edges of the chamber when swaging the plate. The plate, the chamber model, and the covering piece fully finished and ready to solder in place, can be swaged between the die and counter-die at the same time, making a close and easily soldered joint. The opening in the plate is roughly cut when the finishing counter-die is ready for swaging the covering piece, and is finally enlarged and shaped just before the cover is soldered in place.

After the plate has been well swaged to the first die, and roughly shaped to the plate lines, especial attention is given to that portion extending over the alveolar ridge. As a rule, the extreme edge of the plate has a greater length than the plate outline marked upon the cast; it is evident that to adapt one to the other, at least a portion of the surplus length must be cut out, or the plate must be so manipulated as to contract it along this line, or else the amount of surplus length will be represented in the plate by wrinkles. By removing the wrinkles by light blows with the horn mallet as they are formed, the plate can be so adapted that this surplus length may be accomodated by a slit, or a V-shaped piece removed from the plate at the site of the frænum of the upper lip.

By careful manipulation with the horn mallet, and by swaging with blows along the sides of the counter-die, driving the plate toward the die along the alveolar border, this slit may be avoided in favorable cases. While this can seldom be done, it is best to reduce the wrinkling as much as possible in this way; then, when the plate is fairly well fitted to the die, to simply cut a slit with the shears at the centre of the plate, extending it to nearly the top of the ridge, but not over it. If it is cut too far, the edges are apt to separate at the apex of the ridge, leaving a hole to be either filled with solder or covered with a scrap of plate, either of which is objectionable. After making the cut, bend the cut edges apart, and bevel the opposing sides so that when they lap over they will make a smooth joint. If the overlap is excessive, it should be reduced, but a liberal overlap is not objectionable. This slit is not to be soldered

until the plate is fitted to the model and accurately trimmed to the plate lines; if it is closed too soon, it may be impossible to make the edges of the plate fit the model as closely as they should.

The plate should be finished as nearly as possible upon the first die. The first bending of the plate into shape unavoidably subjects the first die and counter-die to an uneven stress; those portions which are first brought into forcible contact with the plate, together with the sharper prominences, become battered. It is on this account that the second die is required. One careful swaging on the finishing die should be all that is needed to make the plate fit the model accurately. If the plate has a soldered chamber, the covering piece, fully finished and ready to be soldered in place, should be in position when this is done. After this swaging, make the outer edge of the plate closely fit the cast at the plate line, and then solder the front slit. In many cases after this has been done, a little manipulation with the bench hammer to bring the plate in close contact with the model at its edges is all that will be needed to make the plate fit satisfactorily.

Testing the Adaptation.—To test the adaptation of the plate, place it on the plaster model, and note first that it does not unduly bind on the alveolar ridge. If the outer edges spring in to the cast the plate will be held firmly on the model, although it may not fit. While the edges must fit closely, they must not bind, and may require to be slightly bent outward to avoid this. Now see that it rests solidly upon the model, that it does not tend to spring up when pressed down, or to rock when pressure is made along the top of the alveolar ridge alternately at the sides, or when pressure is made at the back edge of the plate and on the top of the ridge at the sides or in front. If the plate shows no movement under these tests, if it has a swaged chamber, all that remains to be done is to smooth the edges, clean and polish it preparatory to testing it in the mouth. If, however, it should spring or rock, the cause of this must be sought and the defect corrected. The spring may be due to the outer edge pressing unduly at some point, and holding the plate from contact with the model. When this point is located, a slight bending with the fingers will usually correct it. It not unfrequently happens that the plate will bind upon the outer side of the tuberosity, preventing its back edge from fitting solidly to the model. When this is the case, a few blows with the bench hammer stuck along the back edge of the plate on each side just inside of the tuberosities, while it is firmly held upon the cast, will usually prove effective. There is quite a "knack" in using the bench hammer in giving the finishing touches to the fit of a plate while it is on the plaster model, so as to effect the object without bruising the model. It is something that cannot be described, it must be acquired by observation and practice. That the final fitting needs to be done on the plaster model is not always due to inaccuracy in the metallic dies. All that the counter-die can do is to drive the plate into contact with the die at the moment of impact. There is a certain elasticity in the sheet metal of which the plate is made that gives it a tendency to spring back from the die. Careful annealing, and care-

ful swaging make this less marked, but do not wholly overcome it. The conformation and the corrugations of the plate make this elasticity more marked at some points than at others. It is overcome by bending the plate at these points a little more than enough; at times with the fingers, at other times with the sharp end or riveting blade of the bench hammer, (not the ball end), and again by reswaging with the die temporarily enlarged at the point in fault, so as to give the plate a "set," that is, bent so far that it will be just right when it springs back and is at rest.

Rocking is usually due to pressure at some point inside of the alveolar ridge. While it may be and is often due to some prominent point of the die which is either imperfect in the casting or has been crushed during swaging, it may also be due to elasticity of the plate. The point in fault is usually marked upon the model by a slight discoloration, or it may be located by closely observing the movements of the plate. This point having been determined, place several thicknesses of thin paper on the corresponding point of the die, sufficient to make the plate rock in the same way, but a little more than it does on the model; also scrape away a little from the corresponding point of the counter-die. Now carefully swage the plate, holding the die down firmly upon the counter-die, and striking the die a few hard, solid blows, holding the hammer down firmly so that it does not rebound. If the plate now fits the die solidly, yet still rocks upon the model, the misfit is probably due to an inaccuracy of the die; the model may have been rocked or tilted when withdrawing it from the sand mold, and a new die is the only remedy. Such defects as this are not visible on the die, and are only discoverable during the fitting of the plate.

Before undertaking these manipulations, examine the plate systematically so as to determine the extent and character of corrections required. It not unfrequently happens that some one correction, in itself very slight, will fully correct an apparently serious misfit, if it is attended to first. Observe first, that the plate goes on the model freely; that is, that it is not necessary to press it on. Unless the ridge overhangs the plate should fall off if the model is reversed. Before proceeding further correct any binding of the edges. Now see that the plate is in close contact with all parts of the model which it covers, and also that it does not press harder at any one point than another. To do this hold the model in both hands, the face up and the back part toward you. With the first finger or thumb of each hand proceed as follows: place the finger or thumb of the left hand on the little elevation usually found on the ridge immediately in the front of the mouth, and the finger or thumb of the right hand on the extreme back edge of the plate. If pressing in front causes the back edge of the plate to rise from the model, or *vice versa*, the plate is said to "rock." In doing this it is very important that the pressure be straight and direct. If in pressing at the point indicated in the front of the mouth the pressure should be directed outward, it would raise the back edge of the plate, although the plate might fit solidly; if it be directed inward, it might not raise it, although

the plate might fit very imperfectly. This is a point to be borne in mind.

Keeping the finger on the point in front, press upon the tuberosity and then pass the finger along the ridge from the tuberosity toward the front, and observe whether, on pressure at any point, the plate is displaced or not, or whether it is pressed down at any point, and when the pressure is released, it springs back again. This is termed a "spring," and whether a serious defect or not depends upon its location and extent. Then change the position of the fingers, and press upon, say, the most prominent point of the right tuberosity immediately over the ridge and on the left side, about the location of the canine tooth. Do this for each side. Then press upon each tuberosity; we are apt to find a spring here, owing to the plate being "drawn in;" this may be remedied by slightly "springing" it out; that is, by spreading the back part of the plate, being careful, however, that while correcting this defect, we do not cause another at some other point. While it is not essential that these manipulations should be followed in the order here given, there is a great advantage in always following the same order, and systematically going over a plate and determining where it does and where it does not fit, before any attempt at correction is made.

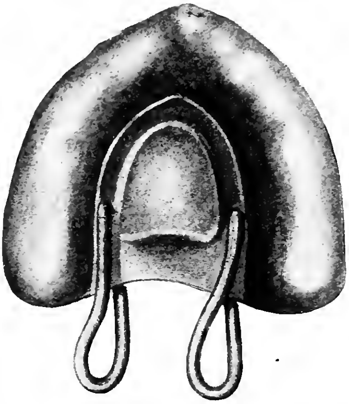
The defects here referred to are those apt to be found in a properly swaged plate, and are due to the mechanical difficulties encountered in changing a flat piece of sheet metal to the complicated form of a dental plate, rather than to imperfections in the tools used. Theoretically, if the plate fits the die perfectly, it should fit equally well the model from which it was made, provided that the die is an accurate reproduction of the model. Practically, no die is absolutely accurate, nor will it retain its first accuracy under the stress of use, nor yet is it possible to swage the sheet metal with absolute accuracy into perfect contact with the die. Good workmanship ensures a close approximation, the dexterous use of expedients and tools completes the task. Reswaging the plate, with the die corrected at the point in fault, is often effective in relieving a rock; at times, however, while correcting one fault it creates another. If the misfit is serious, it is better to make a new die; repeated swagings, with the die corrected, first at one point and then at another, always result in failure.

A spring due to the plate binding on the outside of the ridge may be corrected by placing a few thicknesses of thin paper, dampened so as to bend to the model, over the point where the plate binds, and, placing the plate in position, by striking it a few blows inside the ridge with the face of the hammer. A little practice, much more certainly than extended explanation, enables an observant workman to quickly determine whether the dies are in fault or not, and the best means of locating and correcting remediable defects in a swaged plate after the dies have done all that they can do. No plate should receive its final fitting to the model until after it has been well annealed, as until annealed some portions of the metal are under tension. If fitted before annealing,

the fit is apt to change the first time the plate is heated, as for instance in soldering.

After the plate has been made to fit the model satisfactorily, the edges should receive final attention. They are to be made to fit closely at all points. The riveting blade of the bench-hammer, or a pair of narrow pointed pliers are used to accomplish this. When using the pliers, do not bend in the extreme edge of the plate, but lightly grasp the plate in the pliers and gently bear it in the desired direction. The centre of the back edge of the plate should not be made to press hard; usually this part of the mouth is hard and unyielding, while on either side it is just

Fig. 536



The chamber-piece held in position for soldering by two iron wire clamps. The chamber-piece shown extends to the back edge of the plate.

the reverse. It is, therefore, better to allow it to fit rather loosely. If the plate has a soldered chamber, the edges of the opening should now be made to fit the model closely all around, and after they have been made rounding and smooth, the chamber is to be soldered in place. If due care is used in this operation, it is very seldom that the fit is at all changed in soldering the chamber, while the rigidity it gives to the plate would be a serious handicap if it was soldered in place before the plate was fitted to the cast. While it is not impossible to swage a plate after the chamber has been soldered, to do so usually destroys all the advantage gained by the soldered over the swaged chamber, because of the closer fit of its margins, and is liable to crush it in and seriously mar its appearance.

Attaching the Chamber-piece.—When the plate fits the model correctly, the chamber-piece is placed in position and it is noted whether it is in perfect contact with the plate. This is usually the case if it has been once swaged with the plate, and its position is quite satisfactory. At times, however, it may be desirable to slightly change its position, it is then necessary to refit its margins to the new position, at least for a sufficient distance to solder a portion of its margin. The contact surfaces are first scraped until clean and bright. Borax is applied to the

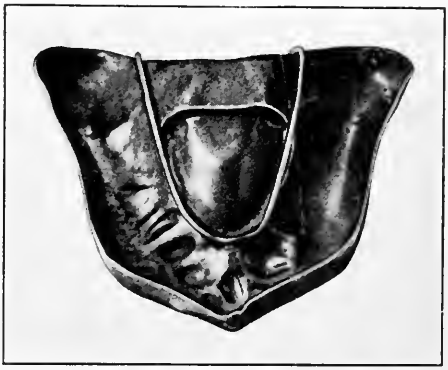
prepared surfaces, and the cap is clamped to the plate by means of two clamps made of No. 16 iron wire as shown in Fig. 536, one applied to either side of the chamber-piece flange, or by a single piano wire clamp (Figs. 537, 538) made to press on the under side of the plate at three points, and to bend over the back of the plate and hold the piece

Fig. 537

Chamber-piece held in place for soldering by piano wire clamp.

in place by pressure upon its centre. This has the advantage of not interfering with the soldering operation, is easily applied, and is effective. Very little pressure is needed to hold the chamber-piece in place; it is well to remember that the plate becomes quite pliable at the temperature at which solder flows, and that if the clamp is made to press too strongly,

Fig. 538



Showing the shape of that portion of the piono wire clamp resting against the under surface of the plate.

it will surely bend the plate. The plate is now placed upon the soldering support, a bed being made for it so that it is supported at all points; if this is neglected, the plate is apt to bend by its own weight. Woolly asbestos wet with water is very convenient for this purpose. When quite wet it is readily molded to any shape, it quickly dries and keeps its shape even when immediately heated very hot. A small square of

solder is applied at any convenient point, preferably at the forward extremity of the chamber-piece, and the broad flame of a blow-pipe is rapidly passed around, beneath, and over the plate until it is heated to a cherry red, when a fine flame is directed against the plate near the solder until the latter begins to fuse, when the flame is thrown upon the flange of the chamber-piece and the molten solder drawn beneath it. As soon as this first piece has flowed sufficiently to tack the chamber-piece in place, observe if the parts are in perfect contact all around. If this is the case the operation may be completed, the clamp being removed if in the way. If a separation has taken place at any point, a mishap that not unfrequently happens, let the plate cool, remove the clamp, and placing the plate on the model, with a burnisher press the flange into close contact with the plate, again using the clamp if necessary to hold the parts in place, and complete the soldering. Place the next piece of solder at a point distant from the first, so that in fusing this second piece, the first will not be re-fused and a risk of the piece changing its position incurred. Small squares of solder are added as may be needed to complete the operation. It is not advisable to place all the solder needed in position at once, unless the operator is an expert, as there is a great risk of the solder running where it is not wanted unless the plate is very evenly heated. Placed one or two little pieces at a time, the solder is much more under control. Especial care should be exercised to prevent the solder flowing anywhere else but under the margin of the chamber. If it flows over the margin, or on the side of the chamber, the beauty of the work is seriously marred, as it cannot wholly be removed; cut away and polished as carefully as it can be, it leaves a mark that will show. If the edges of the margin are left square, and are intended to show in the finished work, it is best to cut the solder in narrow strips, say about a thirty-second of an inch wide and about one-eighth of an inch long, and to so direct the fine flame of the blowpipe that it is all drawn under the margin, leaving the edge of the covering piece sharply defined. When the soldering is complete, examine and make sure that the joint line on the palatal aspect of the plate is well filled.

The plate is now boiled in the acid solution, washed, and dried. It is now tried upon the model. If the soldering has been carefully done, the plate will have suffered no change in form. Every effort should be made that this may be the case, as the plate cannot be reswaged without seriously impairing the usefulness and the appearance of the chamber. Unless the clamps have been unduly strong or improperly placed, or the plate carelessly placed on the soldering support or over-heated, no fitting will be required other than to make the edges of the plate fit more closely. When this has been done, the edges are smoothed and rounded, first with a very fine cut file, and finished with No. 0 emery or sand paper; the surface of the plate is then cleaned and brightened, either by being scoured with white sand used with the fingers, or with brush wheels and pumice stone at the polishing lathe. It is now ready for trial in the mouth.

Partial Upper Plates.—Plates for partial upper dentures are of three varieties: first, those retained by means of a vacuum-chamber; second, those held in position by means of clasps attached to the natural teeth; and third, those in which these two forms of retention are combined. Fig. 534 illustrates the first variety. Great care and judgment are called for in arranging the plate line of partial plates: the peculiarities of such cases are so varied that it is impossible to give any but general directions. The number of teeth to be supported, the character and position of the remaining natural teeth and of the antagonizing teeth, are important factors to be considered. As a rule they should be as small as possible and yet be firmly sustained; at times, however, it is wise to extend the plate beyond the requirements of immediate need in anticipation of further tooth loss. In arranging the posterior edge of the plate, advantage may be taken of any natural depressions in the roof of the mouth in which the edge of the plate may rest and be less in the way of the tongue. A plate supporting any teeth anterior to the molars may end at the interspace between the second bicuspid and the first molar or the middle of the first molar of each side. It is better to well round the corners, forming the outline of the posterior edge in graceful curves, as shown by Fig. 534, and avoid the triangular points, which, while adding nothing to the usefulness of the plate, are so easily bent. Avoid rigidly all fanciful forms; they are entirely out of place.

Partial vacuum-chamber plates are usually much more cumbersome than are clasped plates, and as a rule are not as firmly held in place. They are used in cases where it is desirable to avoid all risk of injury to the remaining natural teeth, or where the remaining teeth, from their position, shape, or condition interdict the use of clasps. The method of their construction differs in no wise from that of clasped plates, except as regards the vacuum-chamber, which may be swaged with the plate, or soldered; in either case the manipulations are precisely the same as those required in constructing the vacuum-chamber of a full plate.

Partial plates supported by clasps are usually made narrow; frequently the posterior line may be drawn almost entirely in the depression of the rugæ, thus placing it where it is least in the way of the tongue. They are often made too small. It must be remembered that unless there is sufficient bearing surface the pressure of mastication will press them painfully into the roof of the mouth. And again, an effort is made to retain plates with but slight attachment to the natural teeth, under the impression that the teeth are thus saved from injury. This is often a mistake; an extra clasp will often hold a plate more firmly, and while making it more comfortable for the patient, will lessen the strain and wear upon the teeth to which it is attached. When the plate extends from one side of the mouth to the other, and is made narrow, some dental mechanics prefer to make two thin plates and solder them together in order to make the plate more rigid and less liable to bend. Others prefer to make the plate heavier and secure

rigidity by adding reinforcing pieces where needed at the time the teeth are soldered. A strong serviceable plate can be made in either way.

The first step in constructing a partial plate is to mark the plate outline upon the model. First consider the position and number of teeth the plate is to support, and the probable number and position of those which it may be required to support in the near future. If a vacuum-chamber plate, the next consideration is the posterior plate line. This should be located to make the plate as small as may be consistent with firm retention, and in all cases must be kept well within the limits of the hard palate. Fig. 534 is suggestive of the form this should take. If supplemental clasps are to be added, the plate must be extended to include the teeth upon which they are to be adjusted. The anterior line of the plate follows closely, in both clasped and vacuum-chamber plates,

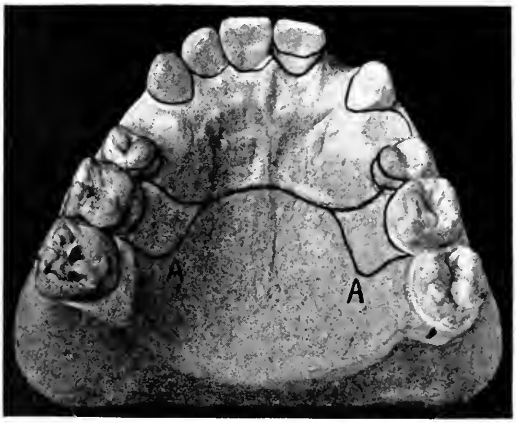
FIG. 539

Partial clasped plate supporting the anterior teeth; showing a backward extension of of the plate to overcome a tendency to drop in front, and to relieve the supporting teeth of a strain they would otherwise sustain.

the lingual borders of the remaining natural teeth, and should extend through the vacant interspaces to the edge of the ridge if plain teeth are used, and over it as would be the case of a full plate if gum teeth are required. It is desirable when making the plate, to let the plate extend quite as far at this point as will be needed, and to reduce its size as may be necessary when fitting the teeth in place. In marking the plate outline of a clasped plate, the teeth to be supplied, and also the teeth selected to sustain it, are to be considered. The plate should be compact, as small as is consistent with comfortable use, and of a form favoring rigidity. These are, however, general considerations only. As a rule the posterior line should not include more than the last vacant space or the last clasped tooth; nevertheless, in some cases, as for instance Figs. 539 and 540, where the clasped teeth are quite short or so shaped that the clasps upon them do not hold firmly, a backward extension of the plate may cause it to be more firmly held; in that case especial care

is needed to so strengthen these portions of the plate that they be not readily bent out of shape.

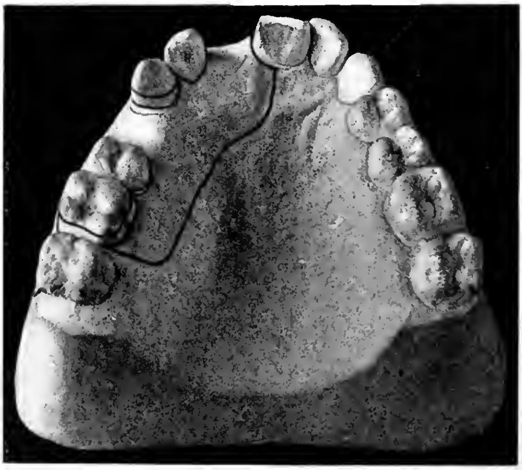
Fig. 540



A partial clasped plate sustained mainly by a short, or unfavorable shaped bicuspid tooth on each side. In such cases, the plate may be held more firmly by a supplemental clasp on a front tooth, a backward extension of the plate, A. A., or a collar clasp on one or more molar teeth, as shown.

The manipulations of swaging a partial upper plate follow closely those of swaging a full upper plate. The least desirable die is selected

Fig. 541



A partial clasped plate confined to one side of the mouth, sustained mainly by a molar tooth. A supplemental clasp on the canine tooth ensures greater firmness, and relieves the molar of a strain it would otherwise sustain. A supplemental clasp may be adjusted to any tooth deemed best, or most available.

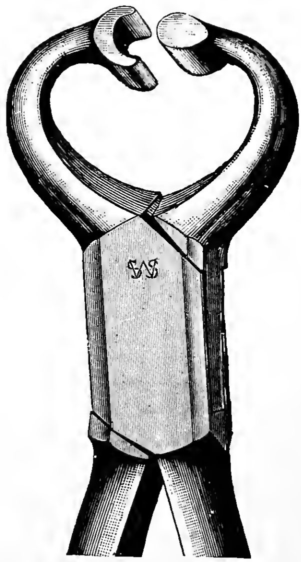
from which the teeth are removed by means of a cold chisel or a hacksaw, supplemented by a coarse flat file until nothing more than an out-

FIG. 542

An unsatisfactory form of clasped plate supporting an anterior tooth and sustained by a clasp on a molar tooth. Owing to the leverage upon the clasp, not only is the plate liable to displacement, but in addition the strain upon the sustaining tooth is excessive. In such cases it is more satisfactory to make the plate as shown by the dotted line, clasping a bicuspid tooth on each side.

line remains. Sufficient should be removed that the plate may be swaged over them without being torn, and yet enough left to plainly mark their position on the plate, as a guide when fitting it to the cast. To prevent the plate sliding backward it is occasionally desirable to let the tooth immediately posterior to the plate line remain, and to make in it a saw-cut to receive the back edge of the plate. This sliding backward of the plate during the swaging process must be guarded against at all stages of making a partial upper plate, especially those embracing only the anterior portion of the cast. They do not, as a rule extend over the alveolar ridge, nor yet are they supported by the flat portion of the palatal vault. Resting as they do upon a sharply inclined surface, their natural tendency is to slide backward as the die is forced into the counter-die. In making a plate such as Fig. 540, it may be treated, in all essential particulars as though it was a full upper plate, the only difference, indeed, between it and a full plate being the extent of surface it covers. In making a smaller plate, such as Figs. 541 or 542, the

FIG. 543



Lower plate-bending pliers, used to bend a lower plate into a gutter-like form preparatory to swaging. They are also used to give a concave form to a metal strip in making a clasp to fit a markedly convex surface.

chief difficulty encountered is usually to hold it in place until sufficiently swaged as to become fairly well fixed in position upon the die. This may be facilitated by sharply bending the edge with a pair of flat pliers so that it rests upon the portion of the die representing the ridge, or in some cases, first fitting it into the counter die. Now and again it may be more securely held by raising upon the counter die with a graver one or more strong burs, just at the edge of the plate, bending them over the plate so as to hold it in position during swaging. A small narrow plate is less manageable with the mallet when fitting it to the die preliminary to swaging, and is liable to displacement during the early stages of this operation. When the plate is well swaged, on the first die, it should be roughly shaped to the plate lines, and then finally swaged upon the second die. Unless it is by its form securely held in position, this must be carefully done to avoid swaging it to a new position and thus spoiling the plate. In all cases until the final swaging is complete the plate should be allowed to extend slightly over the anterior line, as with all possible care there is a slight movement from it. The suggestions as to frequent annealing, and the precautions to be observed to avoid contamination with base metals apply with equal force to all swaging operations. Small plates, and partial plates simple in form, may be constructed upon one die; there is, in such cases, less for the die to do.

After the swaging is complete and the plate fits the model satisfactorily it is then carefully shaped to the plate lines, especially those along the lingual aspect of the remaining natural teeth. As a rule, the plate should fit their margins accurately. In exceptional cases the anterior plate line may be located well within the line of the teeth, as for instance to avoid interference with opposing, teeth, etc.; some operators prefer that it should do this in all cases, holding that cleanliness and comfort are promoted thereby. The plate is now ready for soldering in the chamber, or to be fitted with clasps, if these are to be added, after which the edges are smoothed, its surface well cleansed and prepared for adjustment to the mouth.

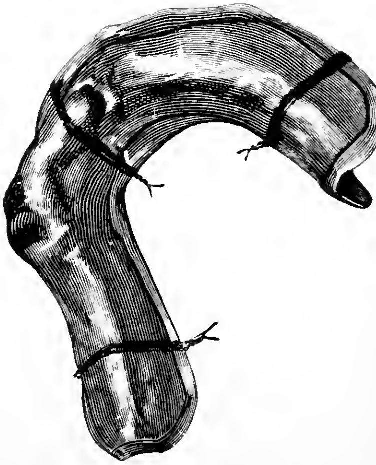
Full Lower Plate.—Before commencing to form a lower plate upon the dies, when the ridge is sharp and prominent, it is an advantage to give it a gutter-like form by use of the lower-plate, bending pliers Fig. 543, or in default of these it may be readily done with the blade of the bench hammer, the plate being held over a V-shaped groove formed in the end of a piece of, hard wood held in the bench vise. The plate thus prepared can be fitted to the dies more rapidly and with less injury to the metal of which it is made than if the work was entirely done upon the dies. Where the ridge is wide, however, it is better to form it over the dies, beginning at the mesial line by first slightly bending the outer edge down with the mallet, and then fitting the inner portion, and so progressively on each side toward the distal end of the ridge. When the plate has thus been made to conform to the die sufficiently well to retain its position it is lightly swaged into the counter-die. As in making an upper plate, this must be done cau-

tiously and any mal-position promptly corrected. If the sheet metal form is correct in shape but little difficulty will be experienced. If, however, this is faulty, the tendency to bend over inside the ridge if the form has been of too sharp a curve, or to the outside if it has not been sufficiently curved, will be pronounced and difficult to overcome. If the error is not excessive, patience, and careful manipulation with the fingers and the mallet may correct it. If the plate is made of a single thickness of metal, the swaging, fitting, and testing the fit, etc., differ so little from that of an upper plate, that further description is unnecessary. It is usual, after a lower plate made of a single thickness of metal is complete and has been tested in the mouth and found to fit satisfactorily, to solder a half-round wire along its edges, inside and outside if the denture is not to be rimmed, and inside and around the distal ends only if a rim is desired. The object of this is not only to afford additional strength, but to make the edge thick and rounded and less liable to cut into the soft tissues. The wire should be quite light, say, one-sixteenth of an inch wide on the flat side. It is fitted and soldered to the plate in the following manner: take a piece of half-round wire sufficiently long for the work in hand, and beginning at a point about an inch from the left distal end of the plate, lay the flat side of the wire against the inside edge of the plate, bending it with the pliers so that it will fit accurately along the edge for about an inch. Do not begin at the end of the wire, but leave enough to well go round the distal end and hold this in place with two bands of binding wire (annealed iron wire of about 24 guage). The binding wire is passed over the plate and its free ends twisted together. Make the edge of the half-round wire lie exactly on the edge of the plate. There is a tendency in the binding wire to draw the half-round wire too far in; this is corrected after it has been made tight, by placing the edge of one blade of a pair of pliers on the binding wire, just beyond the inner edge of the half-round wire, and the other blade at the edge of the plate; a slight pressure will bend in the binding wire and hold the half-round wire securely in place. The binding wire should not be twisted too tight, or it will distort the plate. By twisting it just enough to hold, and then pressing that portion which passes under the plate into the gutter of the plate with a blunt instrument, it will be drawn sufficient tight without risk of bending the plate. This portion of half-round wire is now soldered; in doing this, the plate must be carefully supported at all points to prevent its changing shape during the operation, and the blowpipe flame carefully directed so as not to melt the free portion of half-round wire. A skilful workman will generally at this stage fit the wire all around and complete the operation in one additional soldering; this is not necessary, however; if found more convenient to fit and solder an inch or two at a time, there is but little risk of warping the plate by repeated soldering if the plate is well supported. In applying heat do not direct the flame directly on the wire or it will spring away from the plate. The soldering should be done continuously from the point at which it is commenced. If it is tacked at intervals it is apt to

spring from the plate when the intervening spaces are soldered. Do not use too much solder, if the wire is neatly fitted to the plate and held in position with binding wire at short intervals, very little will be needed. Sufficient heat should be applied to make it flow freely. If the case is to be rimmed omit the wire from that portion the rim will occupy. "Wiring" a lower plate, as this operation is called, is a decided improvement, and, while adding very much to its appearance and strength, makes it more comfortable for the patient. While it is not impossible to reswage a lower plate after it has been wired, the operation is complicated by the presence of the wire, especially if the alveolar ridge is thin and sharp. If due care is used in properly supporting the plate, and avoiding excessive heat, it is seldom, indeed, that there is any serious change in the fit, no more than can readily be overcome without recourse to the dies.

In constructing a double plate, make each plate separately until both are swaged to fit the cast accurately, but do not trim them quite

FIG. 544



Two thin lower plates held together with iron binding wire preparatory to soldering. The underneath plate, as shown, extends a little beyond its fellow so as to form a ledge convenient for placing the solder; this ledge is removed when the plate is finished.

to the plate line, letting the one that is to be underneath extend a little beyond the other so as to form a ledge upon which to place the solder. After annealing, thoroughly cleanse the surfaces that are to be in contact and coat them with borax ground to the consistency of cream, very smooth, and free from any gritty particles. Then place them between the dies in the relation to each other they are to occupy when soldered, placing a thickness of paper on each side so that they will not come in contact with the dies, and swage the two together. The paper is used to avoid the necessity of "pickling" them before soldering. Usually when swaged together they are brought so closely in contact that, if carefully handled, they hold together with sufficient

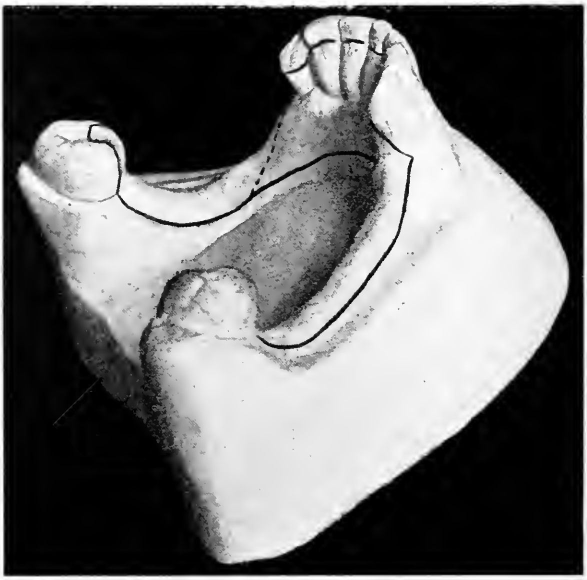
firmness to be laid upon the solder support and soldered without separating. It is desirable that they should do so; if they do not, hold them together with binding wire at, say, three or four points as shown by Fig. 544. In using binding wire for this and similar purposes, it is well to remember that twisting the ends together practically has the tightening effect of a screw; without apparently using much force it is quite possible to draw the edges of the plate together and seriously impair the fit. To avoid this, twist the ends of the wire barely tight enough, and further tighten the wire so as to hold the plates firmly together by slightly bending the wire that passes across the edges, either by pressing it in with a blunt instrument, or slightly by twisting it sideways with a pair of pliers. It is by these means made sufficiently tight without being so rigid as to bend the plate. Always make it a rule to twist the ends of the binding wire in one direction: while it is in all cases a matter of choice, the habit once formed of doing it in a certain way will avoid the annoyance of disturbing the wire, by twisting it in the wrong direction when making the final adjustment before soldering. Usually one wire in front, and one on each side near the distal ends, are all that are required; if, however, there is a tendency in the plates to spring apart at any point, an extra wire or two may be used to restrain them. After adding a little fresh borax at the edges, the plates are adjusted to place on the soldering support, carefully supported at all points so that they shall not bend with their own weight when heated, and a few narrow pieces of solder of the same fineness as the plate, placed along the lingual border of the ledge formed by the lower plate projecting beyond the other. No solder is placed upon the labial and buccal portions of this ledge. The solder is to be drawn through from the lingual side, so as to give assurance of a perfect union of the plates throughout.

The blowpipe flame is passed above it, not on it, until efflorescence of the borax ceases, when a broad flame is applied to the plate until it is heated to a uniform red, when the fine flame is directed against the solder pieces, fusing them one by one. Other pieces are added until there is a uniform line of solder along the lingual edge. Unless one is expert with the blowpipe, it is better not to place too much solder in position at the beginning, as should the plate not be evenly heated, it would tend to flow to one point, and perhaps over instead of between the plates. By adding a little at a time, it is much more manageable. A larger flame is now thrown upon the labial and buccal aspects of the plate until these portions are at a higher temperature than the lingual edge, the heat is cautiously carried forward until the entire mass of solder is seen to flow like water and appear at the labial and buccal portions of the joint, uniting the plates perfectly. This thorough union of the plates is very important, as if a small portion remains unsoldered the plate will be apt to rise up at that point in subsequent solderings, forming what is technically known as a "blister." When cold the binding wires are removed and the plate boiled in the acid solution. The

ledge of the lower plate is trimmed away, using for this purpose the plate nippers, or the points of a very sharp pair of curved shears, completing the trimming with files until the plate outline corresponds with the plate lines on the model; its edges are then rounded, and smoothed with fine sand- or emery-paper.

The plate may be reswaged after soldering, if necessary, but if made to fit accurately before, and carefully handled during that operation, it is seldom that there is any material change in the fit. It is a serious mistake to depend upon subsequent reswaging, and to solder the plates

FIG. 545



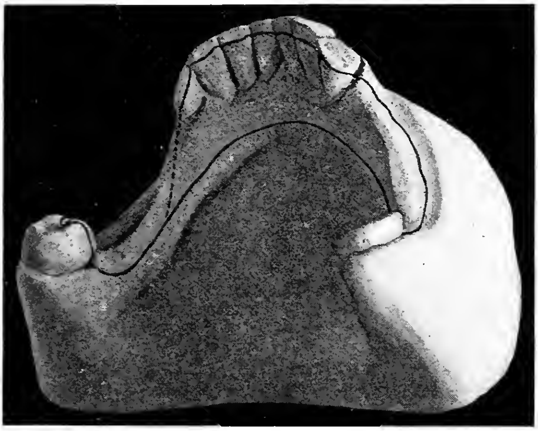
A partial lower plate supporting the posterior teeth, a natural molar tooth on each side remaining. It it desirable in some cases, in order to hold the plate more firmly in position, or to relieve the gums of the pressure of mastication, to extend the plate over the molar tooth of one or both sides, as shown. The reinforcing piece extends backward to the dotted line.

together before they fit the model accurately. After the plates are soldered together they become quite rigid, and while a slight warping may be readily corrected by the dies, it is very difficult to effect any material change in their shape. A carefully swaged double plate should require comparatively little solder to thoroughly unite its separate portions. If by any mischance they should separate during the operation, and an excessive amount of solder be required, it will be apt to make trouble when soldering the teeth; sometimes by running out at the joint, and at other times by melting its way through the plate. The possibility of this enforces the importance of care and exactness at each stage of the work.

A partial lower plate is not as a rule cut away to conform to the gum line of the teeth as is an upper plate, but is allowed to pass up over

them, and is made to fit closely their lingual surfaces. This is done partly to give greater strength to the plate by increasing its width at points where it otherwise would be quite narrow, and partly to allow it to rest on or against the teeth, and thus assist the narrow ridge in bearing the pressure of mastication. It also makes a more comfortable plate, as the edges are not so liable to press into the gum, nor yet are they so perceptible to the tongue. In preparing the first zinc die, the teeth are cut off a little above the plate line, with a sharp downward bevel on the outside, so that the plate will hook over and be less liable to be driven down during swaging. Teeth standing alone, and the end teeth of a series should be rounded on their approximal sides so as not to tear or split the plate. Teeth which are to be fitted with clasps, or when for any reason the plate is not required to extend over them, may

Fig. 546



Showing the first used metallic die for a plate like Fig. 445, prepared for swaging. The molar teeth may be cut off as shown on the right, or a saw-cut may be made as shown on the left, to receive and hold the plate in position during the first stage of swaging. The reinforcing piece extends backward on both sides to the dotted line.

be cut down to the gum line, leaving sufficient only to mark their outline upon the plate. When the teeth to be supplied are in the front, and all together, as in Fig. 539, the manipulation of making such a plate differs but little from that of making a full lower plate. The backings of the teeth and the solder used to secure them to the plate, together with a heavy piece of plate extending from the clasp on either side to the backing of the nearest artificial tooth, added when the teeth are soldered, gives it all the stiffness needed.

When the front teeth are in and the back teeth of either side are to be supplied, as shown in Figs. 528 and 545, the task is much more difficult. The front teeth are filed from the first die nearly but not quite to the plate line as in Fig. 546, and sloped so as to leave a sharp edge, over which the plate is bent so as to hold it in place during swaging. The molar teeth in a case like Fig. 545 are cut off, so as to leave only enough

of the teeth to make a slight indentation in the plate to serve as a guide in filing it to fit around them. In some cases instead of cutting off the molar teeth it is better to make saw cuts as close to the gum as possible, and let the ends of the plate pass into them when fitting it to the die, so as to assist in holding it in place. (Fig. 546.) There is usually some little difficulty in commencing a plate of this kind. It is apt to slip back, or when fitted to the front teeth it does not well cover the ridge on each side. This difficulty is very much increased if the pattern by which the piece of plate is cut is faulty or has not been accurately copied. After fitting it to the die with the mallet sufficiently to permit it being placed in the counter-die, it may be bent and securely held in place by means of burs raised from the lead, and lightly swaged so as to fix it in position. The first effort should be to get the front part of the plate in proper position; this accomplished by bending and holding the sides in their proper place in the counter-die, the difficulty can be overcome by light swaging and frequent annealing. After the plate has been swaged to fully conform to the die, it is very difficult to make any change in its position. In swaging partial lower plates such as these there are three points that require special attention: first, the tendency in the plate to slip down in front, which is continued, unless there is a marked offset at the lingual gum line, from the first to the last swaging of the plate. It is checked by making the plate hook over the front part of the die; and this portion should not be removed until the plate is so far advanced as to be ready to swage upon the second die. The plate should not be filed accurately to the upper front plate line until it is fully fitted to the cast, and is completely finished so far as swaging is concerned. If the front teeth have an outward lean, and there is but little offset at the junction of the teeth and gums, the plate will work down in spite of all care; to provide for this, allow it to extend a full sixteenth of an inch beyond the plate line at this point. Second, a tendency to fold over or form a crease, generally about the position of the canine teeth. This must be closely watched and the fold hammered out as soon as seen and before it becomes fixed. Third, the plate is liable to split at about the same points, and also, in some cases, about the middle of that portion of the plate covering the outside of the ridge on either side. Frequent annealing, skilful use of the mallet, and cutting away the surplus metal at these points as soon as it can be safely done, will usually prevent it. If the split is noticed in time, by cutting it off, if there is sufficient margin, or where this cannot be done, soldering a piece of plate over it, will usually arrest its progress.

It is desirable that those portions of the plate covering the lingual surfaces of the natural teeth fit closely to them and into the interspaces; it is, therefore, important that the dies be accurate at these points. Usually the portions representing the interspaces will need a little carving; this is not so necessary for the first die, but the second or finishing die should be made as accurate as possible. To secure close adaptation at this portion of the plate, proceed as follows: after the plate has been swaged as much as is considered necessary on the first die, and has been

well annealed, place it on the second die and holding it firmly in place, with a hammer or mallet and a bone chaser such as is used in making a swaged vacuum-cavity, drive the plate into the interspaces and the festooned outlines of the gum of each tooth. If the interspaces are deep and sharp, strike light blows going over it a number of times, and if need be, annealing the plate during the operation so as to "coax" it into place. The edge of the chaser will need resharpening, as it breaks down rapidly. Be careful not to cut through the plate, an accident that will occasionally happen, and while not a serious mishap, one that should be avoided. This operation usually bends the plate very much out of shape, and sometimes changes the position of that portion extending toward the distal end of the plate. On this account the plate should be only approximately trimmed to the lines until it is completed and the plate well swaged on the second die. After the plate has been thus fitted to the lingual surfaces of the teeth, it is fitted on the second die and lightly swaged. First, see that it has not materially changed its position, that the front portion has not been driven down, and that the posterior portion reaches the plate line on both sides of the ridge. Any mal-position is readily remedied at this stage, by readjusting the plate to position in the counter-die and holding it in its proper place by burs raised along its edge while it is again swaged. Next, examine the plate on the model to see that it fits the model and die alike. It may be that at some points the die may have "dragged" slightly, which will be shown by a space under the plate at that point when the plate is placed upon the model. If this is the case, carve the die so that the plate fits both alike; this can be done very accurately by carving the die, placing the plate on it, and with a hammer making the plate fit the die at the point carved, and testing it on the model, repeating this until they are both alike. The points needing special attention are around the teeth next the spaces to be supplied, the interspaces, and the edges of the plate. When this has been done, again go over the front portion of the plate to make it fit against the lingual surfaces of the teeth accurately, using a steel chaser if necessary, holding the tool so that it will carry the plate into place, and not simply make an indentation into it or cut it through. The plate is now thoroughly swaged on the finishing die, and made to fit the model accurately. It is then ready for the reinforcing piece. In some cases that portion of the plate extending inside the teeth is very narrow and so nearly flat that three thicknesses of plate are needed to impart the required stiffness. In other cases it is wide, or so corrugated that two thicknesses of comparatively thin plate are quite sufficient. If three thicknesses are deemed necessary, the first reinforcing piece is made narrower than the plate lines, and to extend only a short distance beyond the last tooth of the series on each side. After being swaged it is filed to shape, and its edges all round filed to a feather edge. It is then adjusted to place on the plate, (both it and the plate having been made clean and prepared for soldering), held by a clamp or with binding wire as may be most convenient, and a trifle of solder fused at some

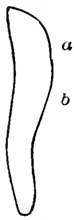
point where the two are in contact, preferably at a central point, with the object of holding them together so that they can be swaged together. After this, the soldering is completed. The second reinforcing piece is now made. This should be larger, fully the width of the plate lines as far as the natural teeth extend, tapering and extending beyond the last tooth of each side to fully half an inch, as shown by the dotted line, Figs. 545 and 546. No special care is taken to make this fit into the interspaces, but as soon as it is sufficiently swaged to permit its being properly shaped, it is tacked to the plate with a small portion of solder and swaged with it. The denture is more easily kept clean, is more comfortable to the tongue, and has a more artistic finish, if this portion of its lingual surface is smooth and even; it is not desirable, therefore, that the front portion of the reinforcing piece should be swaged into the interspace with the same accuracy as was the plate. It is worthy of note that the reinforcing pieces are not made to fit the model; they are fitted to the plate, and as the surface of the plate against which they fit differs very much from that which fits against the model, the plate should be in place on the die, and be considered as part of the die, when the reinforcing pieces are swaged. Before attaching the reinforcing piece to the plate, the upper edge of the tapering ends should be well bevelled. The plate should extend slightly beyond the plate line as far as the reinforcing piece extends, so as to provide a ledge on which to place the solder; otherwise, the solder is liable to flow under the plate instead of between it and the added piece. If the two have been tacked together it is seldom that a clamp is needed when the final soldering is done. As in soldering a double plate, every care and effort should be taken to make the solder flow thoroughly, and to unite every portion of the two surfaces in contact with the least possible amount of solder. As to accomplish this the heat must be quite high, it is important to thoroughly support the plate to prevent its warping, especially if it is of silver. With proper care, it is seldom that the fit is materially altered. After the reinforcing piece is soldered, and the plate has been cleansed from the borax, etc., it is ready for final adjustment to plate lines, and the portion beyond the reinforcing piece is bound with half-round wire. This done, the plate is fitted to the model, the edges neatly rounded and made smooth and its surfaces thoroughly cleansed, when it is ready for adjustment to the mouth.

CLASPS.

The metal of which clasps are made should possess stiffness and elasticity in a marked degree; it should also be tough and free from brittleness. An alloy of gold with about two grains of platinum to the pennyweight answers the purpose exceedingly well; if carefully made of pure metals it is tough, stiff, and, even when well annealed, is as elastic as a piece of spring-tempered steel. In practical use clasps are

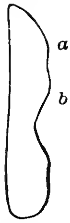
subjected to considerable strain; in addition to this, from their position, they are constantly liable to accidents while the denture is being handled and cleansed by the patient. To withstand this the metal must possess tenacity. To test its tenacity, grasp a corner of the well annealed metal firmly with a pair of flat pliers and quickly bend it to a sharp right-angle. If this causes the least sign of a break, the metal should be rejected. Other alloys than that of platinum and gold have been suggested and used for silver dentures on the score of economy. While they have answered the purpose, none possess any practical advantage over the more generally used alloy of gold and platinum, while the slightly smaller cost is overbalanced by the difficulty of profitably utilizing the scraps and filings. Laboratory practice is simplified by making an eighteen carat gold and platinum alloy the standard for all clasps used on soldered dentures, whether of gold or silver. The alloy is used for clasps in the form of plate of about No. 25 gauge—seldom heavier than No. 22, and seldom lighter than No. 27—and in the form of half-round wire. Half-round wire is used when the teeth are short, so as to obtain strength with a narrow clasp, and when the clasp passes around the tooth in an irregular line to avoid pressing upon the gum, or to obtain a firmer hold upon the tooth. The peculiar shape of half-round wire permits its being bent in any direction, and on this account it can be more readily fitted to short molar teeth, and a clasp made of it will often grasp them far more firmly than would one made of plate. The thickness either plate or wire should possess depends entirely upon the work required of them and the position they occupy. It should never be made so heavy as to be practically rigid: the free or unsoldered porton of a clasp should be elastic, not only to firmly grasp the teeth, but also to slightly yield under severe strain, and thus ease the strain upon the tooth to which it is adjusted.

FIG. 547



A properly shaped clasp.

FIG. 548



A clasp improperly shaped. Having its plate edge filed away to fit the gum makes this portion the weakest point, impairing its usefulness by destroying its elasticity, and making it liable to fracture.

The strongest portion of all clasps should be where they are united to the plate, and from this point they should taper to the free ends. It is a common and a serious fault in making clasps to file from the under edges where they pass around the appromixal surfaces of the teeth, so as to keep them from pressing unduly upon the gums, without at the same time so shaping the upper edge that the clasp shall be of uniform strength. The effects of this is to make a weak spot at a point where the clasp should be the strongest; all the bending takes place at this weak point, not only impairing its value as a clasp, but invariably causing it to break. If after properly shaping the lower edge the clasp is reduced in width toward the free end so that the hollowed out

portion ceases to be the narrowest part of the clasp, its strength, usefulness, and durability will be very much increased. A properly shaped clasp, opened out, would approximately resemble Fig. 547; one with the defect referred to is represented in Fig. 548. In each case the attachment to the plate extends from *a* to *b*.

If it is necessary that the clasp be narrower near the plate than at the free end, as is sometimes the case, the narrow part should be made correspondingly thicker—not by soldering an extra piece upon it, but by making it of thicker plate, and filing the wider portion thinner, so that in proportion to the strain upon it, it will be of uniform strength throughout, and as free to bend at one part as another. Before beginning to make a clasp carefully examine the shape of the tooth, its position in the mouth, and its relation to the plate, so as to form an idea of the direction and amount of strain it will be required to resist, and from this regulate its size, shape, position, and strength.

In making clasps, fit them to the teeth before soldering only so far as is necessary to adjust them to their proper position—usually only the palatal and approximal surfaces, anterior and posterior—leaving that portion which is intended to pass around the buccal or labial surfaces straight. The object of this is, first, that they may not bind upon the teeth so tightly as to prevent their being readily removed from the model without change when cemented to the plate prior to investing for soldering; and second, for the reason that in many cases they are more securely held by the investment when so made. The remaining portion of the clasp may be fitted approximately either to the model, or when the plate is adjusted to the mouth, but only so far as to lightly retain it in place, the final fitting being left until the case is entirely finished. If prior to this they are fitted so as to hold the plate firmly, it gives a great deal of extra trouble in adjusting the teeth, without any corresponding advantage.

In making clasps the following tools are needed: a pair of strong, but not too massive round nose-pliers and a pair of narrow-beaked flat pliers, with the inner edges of both blades rounded so as to remove the sharp square edge. These are essential. A tool known as a clasp bender is frequently useful, as is also the lower plate-bender, (Fig 543), the former is used to concave the clasp along its length to fit a markedly rounded surface, such as is occasionally found on molar and bicuspid teeth. If this tool is not at hand, the same effect may be produced with the riveting blade of the bench hammer.

In making clasps for very difficult cases it is occasionally necessary after fitting them with the pliers, to swage them between dies: this is required when the surfaces to be fitted are rounded or the shape of the tooth very irregular.

It is not usually necessary to make a pattern by which to the cut the clasp material to shape. It is better to prepare a strip of plate a little wider than the finished clasp is intended to be, so as to allow for filing the edge to fit the gum at the neck of the tooth, and long enough for several clasps; in fact a little longer, as it is quite difficult in practice, without

unduly wasting time, to make the first bend precisely in the right place; it is always best, therefore, to have a little margin for possible errors. Having the strip long makes it very much easier to handle. In case the lingual surface of the teeth are markedly bulging, as is frequently the case with upper bicuspids and molars, a more accurately fitting and more effective clasp may be by first curving the strip making the side that fits against the tooth concave, so that it will fit over the bulging portion of the tooth. This may be done with the blade of the bench hammer, resting the strip upon a lead counter-die or on the anvil, but more conveniently by the lower plate-bender represented in Fig. 543.

In fitting a clasp to the molar tooth, such as that seen in Fig. 547, lay the strip flat against the anterior approximal surface of the tooth, allowing one end to project beyond the buccal surface as far as it is intended to pass around that corner of the tooth, and mark with a pencil or point or note with the eye the position of the first bend to be made in fitting the clasp to the palatal surface, and with the round or narrow-beaked pliers or clasp-benders, as may be preferred, bend it, but at first not quite as far as necessary, so as to be able to correct any error made in the first bending without unduly straining the metal by bending it back again.

The clasp is now placed as nearly in position on the cast as its shape will permit. Note where it should be bent, so as to pass around the posterior approximal surface, and cautiously bend it into the required shape. Usually it will be necessary to file the lower edge of the clasp at certain points to allow it to fit well down to the gum at the neck of the tooth, especially at the palatal side; it is desirable to do this before the clasp is accurately fitted to the tooth, as it may somewhat change its position.

This may now be done, at least so far as to allow the clasp to fit well down to the neck of the tooth, as it should do in the case we are now considering. In many cases the neck fit of the clasp is most important; fitting well down to the gum-line and close to the tooth, enables it to sustain a plate firmly and comfortably, without that strain upon the tooth inevitable when the security of the plate depends upon the clasp firmly grasping the tooth. The clasp fitting under the bulging portion of the tooth holds by interlocking with the body of the tooth, while it is free to yield to slight movements of the plate incident to its proper use.

When a tooth stands alone, as represented in Fig. 539, it is a matter of but little moment on which side of the tooth we first make the clasp fit accurately; but when it passes between the teeth, after the clasp is roughly fitted, make the portion between the teeth as accurate as possible, and proceed to readjust the clasp from this point until it fits the tooth satisfactorily, as far round as it is necessary that it should before soldering it to the plate.

Invariably begin to make the clasp at its shortest end; when this end terminates between two teeth, but does not pass between them, make it

pass into the interspace as far as possible; it gives the clasp a much firmer hold upon the tooth.

As a rule, clasps for lower teeth are not fitted close to the gum line: the teeth are usually longer and more wedge-shaped than are the upper teeth. To hold firmly the clasp must embrace the tooth nearer the cutting edge: this is made necessary by the fact that the neck is so much smaller than the crown. It is frequently necessary to make little hooks or lugs to catch over the grinding surface of lower bicuspids and molars in connection with the clasps to prevent the plates pressing too hard upon the gums. These may either be made with the file—which, when it can be done, is the best plan—or they may be soldered on after the clasp has been soldered to the plate and fitted to the mouth. It is always desirable to avoid using solder for any purpose on that part of a clasp which is intended to act as a spring, as it impairs its elasticity by making it rigid at that point. When clasps are applied to partial lower plates carrying posterior teeth only, especial care is needed in their construction to conteract the natural tendency in such plates to slide backward. In clasping upper teeth that are markedly wedge-shaped, as for instance, the canines, and all teeth where the gum has receded and exposed the neck, the clasp should be made to fit the tooth at its largest part; the importance of this is self-evident. In some cases it is desirable to have the clasps as far above the line of the plate that it is necessary to connect them by a narrow strip of plate, forming what is known as a "standard clasp." Occasionally, especially for lower plates, when the axes of the clasped teeth are at such an angle as to interfere with the adjustment of the plate and clasps, the difficulty may be overcome by making the standards elastic, by making them of half-round platinous gold wire. Standard clasps are not as a rule desirable. They are not as cleanly as is a clasp soldered directly to the plate, and are more liable to accident.

Stay or collar clasps, are useful appliances to assist in supporting partial vacuum-chamber plates, to assist in supporting clasped plates, or where a clasp is needed and no space exists through which a clasp may be conveniently passed. They are frequently employed upon the palatal surfaces of bicuspids, not unfrequently in pairs, each one, however, being separately soldered to the plate with each end free. In fitting these partial clasps bear in mind the purpose for which they are used, so as to take advantage of every little point that may increase their usefulness. In fitting them to the bicuspid teeth, to make them fit very accurately at the neck, the model may be slightly scraped at this point before the clasps are adjusted, so that they will spring over the bulging portion of the teeth when placed in the mouth. Let the strip of plate from which they are made be amply wide, not too wide for proper adjustment, but quite as wide as the tooth is long, unless it is of unusual length. It may be that when the plate is fitted to the mouth the clasp must be quite narrow, but if so made before it is soldered, being so lightly held by the investment, it will probably move during that operation sufficiently to make it useless. If made wide, fitting well at the neck of the teeth, not

only is a change of position less likely to occur, but, if when fitting the plate in the mouth, it does not press as firmly against the teeth as it should, it may be grasped by the pliers and borne outward until it does. The free edge is then shaped, being cut away so as to not extend beyond the bulge of the tooth at its palatal surface, but embracing its approximal surfaces nearly to the cutting edge. It not unfrequently happens that partial clasps upon bicuspid teeth, although fitting accurately, spring the plate down until the portion extending beyond the bulge is removed, they then take hold under the bulge, and hold wlth great firmness. When they are used in pairs, the ends which pass into the interspace must be filed thin, so that both clasps will pass well in: it is a mistake, and a common one, to make one clasp short at this point. When soldering these partial clasps to the plate, solder sufficient only to make the union secure, both ends must be left free. Now and again stay clasps upon the bicuspid teeth on both sides of the mouth may be used to advantage to wholly sustain a plate. Favorable cases are where the gums have receded moderately and the teeth are quite firm. The clasps in these cases pass over the bulging surfaces of the teeth, and impinging lightly upon the narrower portion of the teeth, will hold a denture satisfactorily without exerting any marked outward pressure. When the gums are normal, and the root portion of the teeth not exposed, this construction is seldom admissable; to secure firmness the clasps must press against the teeth; the denture then acts like a regulating appliance, and in a little while the teeth are pressed outward and no longer sustain the denture.

Placing and fitting clasps requires accurate judgment; while the general construction is the same in all cases, the endless variety of conditions met with require corresponding variations. First consider the object the clasp is designed to accomplish, and with this in view, proceed with its construction.

When all the clasps required by the denture are fitted to the teeth, they are adjusted to the plate in the following manner. Place the clasps on the model, one at a time, and file away the plate where it impinges upon them until it fits in place on the model with all the clasps in position. The next step is to cement the plate and clasp together so that they can be removed from the model to invest for soldering. In ordinary cases hard resin-and-wax cement will be sufficient; for difficult cases shellac, being stronger and more rigid, is to be preferred. In using either it is best to first heat the plate and clasps quite hot and run a little of the cement upon them, otherwise the cement may not hold firmly. While the plate and clasps are accurately in place on the model unite them with the cement; allow a few minutes for it to chill, then carefully remove them from the model, being very watchful that their relative positions are not changed. The cement may be chilled with cold water, and is then made more rigid, but with the disadvantage that if it should fracture in removing the plate from the model, the plate and clasps must be thoroughly dried before the cement is reapplied. In some cases it is best not to attempt to cement all the clasps at the same time, but to take

those first which may readily be removed with the plate from the model, solder them, and then adjust the others. Those clasps in which the neck-fit is important, especially partial clasps upon bicuspid teeth, may be settled in position upon the model by a few sharp, but not severe, blows with the bench hammer just prior to cementing them to the plate.

Cases are met with occasionally where the clasped teeth occupy such a position that the plate and clasp cannot be removed from the model without the cement breaking. In such cases use as much shellac as possible, let it get quite cold and rigid so that it will break without bending, and readjust the plate and clasp after their removal from the model, for which the fractured surfaces furnish a fairly trustworthy guide. It has been suggested that if the case cannot be removed from the model it cannot be placed in the mouth. While this is true of extreme cases, it is not generally so; the teeth in the mouth are not so rigidly fixed as are their counterparts on the plaster model.

After the plate and clasps are removed from the model they are invested for soldering in a batter of about four parts plaster to five of white sand. In placing the investment especial care should be taken to so imbed the clasps that they will not be drawn in toward the plate during soldering; and also that the relative positions of the clasps and plate are not changed by the pressure of pressing them into the investment.

When the investment is thoroughly hard, the cement is chipped away, and the investment so carved that the blowpipe flame can readily reach all points which are to be soldered. Fill with plaster, or whiting mixed with water to the consistence of cream, as much of the joint between the clasp and plate as it is intended shall remain unsoldered. It is not desirable at this stage to make a very strong union between the clasps and plate, but simply to unite them at some point at which they are known to fit the teeth and which will be included in the final soldering. It is desirable that they be left as free as possible so as to permit an accurate adjustment when the plate is fitted to the mouth. Now scrape the surfaces over which the solder is to flow, making them clean and bright, coat them with borax, lay over the joint a small piece of plate and over this a small piece of solder. While clasp soldering can be done entirely with the blowpipe without previous heating of the investment, it is a decided advantage to first make the investment nearly "red hot". If this is not done, and the blowpipe flame directed immediately toward the part to be soldered, the uneven heating of the metal, or burning away of the investment is apt to change the position of the clasps, or by displacing the plaster placed in the joint will permit the solder to flow further than is intended. If the mass of the investment is quite hot the solder flows quickly, and without an excessive application of the blowpipe flame. First use a broad flame, and endeavor to heat the clasp and plate equally. As the heat approaches that required to fuse the solder, use a more pointed flame and concentrate it upon the parts to be soldered, but

not directly upon the solder. If the solder is heated more than the plate, it melts into a ball, and it is then difficult to make it flow. When in this condition more heat is required, and sometimes the parts are made so hot that when it finally flows some of the surrounding plate is also fused with it. This is especially apt to occur if there is a large amount of solder in position. This is one reason for advising a small piece at first. After the solder has once bridged the joint there is no difficulty in adding more to make the joint strong. Sometimes, when the solder has "balled-up," as this condition is technically termed, it is best to add another small piece and endeavor to make this flow over or into the joint. If this fails, do not continue to add solder, but, with a pointed steel or iron rod, say, about one-eighth of an inch in diameter, and ten or twelve inches long, provided with a suitable wooden handle, flatten the ball of solder and direct it into place, at the same time by skilful application of the blowpipe flame make the plate hot at the point over which the solder is desired to flow. The solder always tends to flow to the hottest point: advantage is taken of this in all soldering operations and its flow directed by the skilful application of the blowpipe flame. The iron or steel solder director is a useful tool. Made of iron or steel, it is not apt to alloy with the solder although the solder tends to unite with it slightly. Before beginning to solder, see that this tool is at hand and in proper order; it should be filed to a moderately sharp point, and all adhering solder filed off clean so as not to contaminate the new solder. Now and again moving it over the point where the solder should flow with a rubbing motion, or with a wiping motion moving the molten solder toward the joint very much facilitates a successful soldering.

When the soldering is completed there is no objection to quickly cooling the plate in water to save time. It is then "pickled" in acid and cleaned either by rubbing with white sand and water with the fingers, or at the polishing lathe with a brush-wheel and pumice-stone. The outer ends of the clasps are now made to fit the teeth, and their upper edges filed to the size and shape desired, leaving, however, a little margin for any changes that may be necessary when adjusting the plate to the mouth. It is well to remember that it is far easier to take off a little more than to add. After rounding and smoothing the edges with sand-paper, if the plate and clasps fits the cast accurately, it is ready for adjustment in the mouth.

TRYING THE PLATE.

After the plate is finished on the model, the next step is to adjust it in the mouth, not only to test the accuracy of the impression, but also to make any changes that may be required to secure a satisfactory fit. This is more important with the plate for a soldered metallic denture than with one for a denture that is either cast or molded, as in this case

the plate is not a mere model, but is designed to become a part of the denture. and should, therefore, be made to fit as accurately and as comfortably as possible.

In an upper or vacuum-chamber plate, after relieving any points where it presses unduly into the soft tissues, or if it is a partial plate where it impinges upon any of the remaining teeth, test the fit in much the same way it has been tested on the model; this should be done before testing the effectiveness of the vacuum-chamber. This is important. In many cases a moderately strong suction will hold the plate so firmly that a serious misfit may pass unnoticed, and the mortifying failure that results when the denture is finished and its stability tested in the act of mastication will probably be incorrectly assigned to "warping during soldering."

Examine closely the back edge of the plate. In some mouths the centre is quite hard and rigid, while at either side the tissues are quite soft and yielding. Changes may have been made to provide for this when preparing the model for making the dies. If it has been overlooked, or the changes made prove not sufficient for comfort and stability, any needed corrections may now be made. Allowance must be made for the changes the pressure of usage will make: a plate that fits quite loosely at this point may press uncomfortably hard after a few days use. Any needed changes in this respect are readily made at this time by bending the edge of the plate with the pliers, to make it press harder, or to relieve undue pressure. If there is much difference between the fit of the plate on the model and in the mouth, it is probably due to a faulty impression, and the only remedy for this is to obtain a better one.

When the central hard ridge is well marked and the plate presses upon it unduly, it is sometimes necessary to reswage the plate with a thickness of paper between it and the die at this point, or an additional piece of plate may be soldered back of the chamber and extending to the edge of the original plate, to allow for filing at this point if found necessary after the denture is finished; or a sufficient relief may be obtained by placing a few thicknesses of paper under the plate on the plaster model and gently striking each side alternately with the bench-hammer, at the same time holding the plate firmly to the model. If the undue pressure is at the extreme edge of the plate, it may be relieved with the pliers, but it is more frequently so far inside of the edge that they are not available. In a few cases the mouth is intolerant of a plate, its presence causing severe nausea even though it does not encroach upon the soft palate. Persistent use will often overcome this, but not always. Usually the central portion of the mouth is more sensitive than is the alveolar ridge, and advantage may be taken of this to secure a more comfortable plate by extending it far back on either side and leaving the roof of the mouth free, or, in other words, making it horseshoe-shaped.

Occasionally the edges of the vacuum-chamber press too hard; this is easily relieved, and its correction had better be left until the denture

is finished; the smoothing of these edges in the final polishing may be all that is needed.

Examine the edges of the plate and see that they are in close contact with the gums, and that there is sufficient room during the various movements of the mouth for the frænum in front, and the "strings" on either side just back of the canine teeth. In partial cases see that the edges fit snugly against the remaining teeth. In partial cases, when a vacuum is produced, see that the plate fits closely to the gum where it extends through the interdental spaces; it not infrequently happens that a vacuum-cavity plate is slightly displaced, when drawn firmly to place; usually it is brought forward. This is more likely to happen with a small plate in which the vacuum-chamber is well in front; in partial cases this movement is occasionally so marked that it is necessary to take an impression with the plate in place in order to obtain an accurate guide for arranging the teeth.

In full lower plates, first see that they fit solidly, and are without rock or spring, that the edges are in contact with the gum at all points, and yet do not press unduly. The lingual edge immediately back of the incisor teeth, and the lingual aspect of the distal ends, are points that frequently require bending inward. These points are often markedly undercut, and are points where the plate is apt to be inaccurate owing to inaccuracy of the model, inaccuracy of the die, or failure to thoroughly swage the plate into the undercut. In cases where the undercut is quite marked the plate cannot be swaged accurately by the counter-die alone. A blunt pointed chisel or chaser made of bone (a tooth-brush handle answers admirably), and at times a pair of pliers, will be required to make the plate fit accurately at these points. Next make sure that there is ample room for the frænum of the tongue when the tongue is raised as in swallowing, and that the back part of the plate does not encroach upon the cheek, or interfere with the movements of the tongue. Lower plates are frequently made wide at the distal ends, under the idea that the increased width adds to their stability and comfort. This is seldom the case; but few mouths will tolerate a lower plate wider at the ends than the face of the alveolar ridge.

In partial lower plates see that the plate fits closely to the teeth upon which it extends. Partial lower plates should be tried in the mouth and accurately adjusted before the reinforcing pieces are added, so that any changes found necessary can be readily made; after the plate is "doubled," "wired," or "reinforced," it is very difficult on account of the stiffness imparted by the additional thickness and by the solder, to make any material change in its shape.

The clasps on all plates retained wholly or in part by clasps should be filed into shape and bent around the teeth as far as they are intended to go at this stage, but should not be fitted closely to the teeth, except so far as they are intended to be soldered. To permit the ready removal of the plate from the mouth it is best to leave the clasps rather loose until the denture is finished, especially if it is desired to adjust the teeth in the mouth before they are soldered to the plate.

In adjusting the clasps especial attention is needed to so shape the ends that they will hold firmly, and yet as far as possible be out of the way and out of sight, and at the same time be confined to those portions of the tooth least liable to injury. In bicuspid and canine teeth there is usually a more or less marked curve of the labial or buccal face, and frequently these teeth are markedly wedge-shaped. When this is the case, let the clasps be sufficiently wide on the approximal surfaces, that after the plate sinks down a little as all plates do after they have been worn a short time, they will still embrace the widest part of the tooth, and the ends that extend on the buccal or labial surface may be cut away from the upper edge (the edge nearest the occlusal surface of the tooth), so as to spring over the curve of that face of the tooth. This not only gives a firmer hold, but makes it far less conspicuous. In all cases, no matter how much the clasp may require to be cut away to avoid impinging upon the gum or from any other cause, be careful to so shape it that the strongest part shall be where it is soldered to the plate, and that it tapers off from this point to either end, as previously suggested.

In upper plates the clasps are designed mainly to hold the plate firmly to the roof of the mouth; in lower plates their chief function is to hold the plate in position, to counteract the tendency in these plates to slide backward, and also where hooks or catches are added, to relieve the pressure upon the gums. They also hold the plate down, but this is usually their least important function. This distinction in function between upper and lower clasps should be borne in mind when making or adjusting them.

There are many minor points to be considered when trying in a plate that are self-suggestive, the points enumerated are the more important ones, and are mainly concerned with accuracy of adaptation and the patient's comfort. Beyond this, especially in partial cases, much may be observed that will be of assistance in completing the work. Inaccuracies of the model that impair its usefulness as a guide in arranging the teeth should be corrected; the condition of the gums upon which the teeth are to rest should be noted, and the model carved as may seem necessary, so that the artificial teeth or gums will properly blend with the natural ones. Any marked peculiarities to be considered in arranging the teeth should be noted and marked upon the model, so that later they may not be overlooked.

The shade may now be selected, the kind and character of teeth decided upon, and the bite-impression taken.

TAKING THE BITE.

Apart from the fact that in full soldered dentures the operation technically known as "taking the bite," is conducted with the plates that are to be used in constructing the denture, and not on temporary trial plates, as is the case with molded or cast dentures, the procedure is pre-

cisely the same for soldered, cast, and molded dentures. In partial cases it may be done when the impression is taken or immediately after the plate is fitted to the mouth, and while it is still in position, as may be most convenient. In a few exceptional cases where the bite is very close, or where the occluding teeth interfere, a more satisfactory bite may sometimes be obtained if taken with the plate in position; mainly because there is less risk of misplacing it upon the model prior to making the articulating model. The method of taking the bite, the precautions to be observed to secure accuracy, and the construction of the articulating model, are fully considered in Chapter X.

SELECTING THE TEETH.

As the general subject of selecting teeth is elsewhere in this work considered at length, it is unnecessary in this place to do more than briefly consider those purely mechanical matters especially concerned with selecting teeth for soldered dentures. Inasmuch as the teeth of a soldered denture must rest upon and fit closely to the plate, more care is needed in their selection than in selecting teeth for a molded or cast denture. In the latter case, but little is required beyond satisfying the artistic requirements of the case; as the plate is made to fit the teeth after they are finally arranged in position. In a soldered denture, on the contrary, the teeth are accurately fitted to the plate by means of various forms of grindstones, and in addition to satisfying the equally exacting artistic requirements, the purely mechanical problems this involves must be considered when the teeth are selected. When plain teeth are used this involves but little more than sufficient extra length to allow the teeth to fit the plate solidly throughout the area of contact between the tooth and the plate, The selection of gum-teeth is more complicated. There must be sufficient body back of the gum to permit the porcelain to accurately fit the plate over the whole area of contact when the tooth is in its proper position. Considerations of cleanliness as well as of strength calls for this accurate adaptation of the porcelain to the metallic plate. The usual form of teeth made especially for soldered dentures requires a metallic backing reaching nearly to the cutting edge. In a close bite this must be considered, especially when selecting anterior teeth for an upper denture, and teeth selected sufficiently thin to permit this without making the tooth unduly prominent.

The position of the pins must also be noted. Teeth for plate-work usually have two, arranged either transversely or perpendicularly, and are technically known respectively as cross and straight pins. Very large or very long teeth have three or four, usually vertical. The cross pin teeth are designed for cases of close bite, and now and again serve a useful purpose. They should be avoided wherever possible, as they are inherently weak from the following reasons: first, the position of the pins weakens the tooth at the point where it is most liable to break

from stress of use or strain during soldering; second, when arranged in place both pins are brought near the plate, making the strain upon the pins and the porcelain greater on account of the increased leverage between the pins and the cutting edges, and furthermore, this strain, in time stretches the metal of which the pins are made and permits a slight rocking movement of the tooth which causes the pins to break between the backing and the tooth. They are least objectionable in short molar and bicuspid teeth, and in anterior teeth very broad in proportion to their length. It is a common error to always select cross pin teeth for a close bite. In all such cases the backings should be extended to near the cutting edges, so that they will relieve the teeth of part of the strain. When this is done there is no advantage whatever in cross pins.

The straight pin teeth are more reliable, mainly from the fact that the upper pin is closer to the point at which the force is applied, and the leverage upon it is, therefore, less.

The position of the pins is also varied. Some teeth are made with the pins nearer the cutting edges, than are others, and in some, the pins are placed nearer together. Advantage should be taken of this, and teeth selected with the pins in the best position to resist the strain incident to constructing the denture and the strain of constant use. Pins near together are much more liable to cause fracture of the tooth during soldering, and do not so well resist the strain of constant use; straight pins so placed that they come near to the plate when the tooth is in position, while there is considerable space between the upper pin and the occlusal edge, provided that the backing can be extended so as to protect the tooth, are to be avoided; in all such cases teeth with pins better placed can quite as readily be used. While very thin teeth should be avoided on account of their weakness, where they are not especially required, very thick teeth are objectionable on account of their clumsiness. Porcelain teeth mounted upon a molded or cast base are, as a rule, better supported than are those upon soldered metallic plates; they are less strained during the process of construction; their initial strength and their ability to resist strain is, therefore, less important.

Close attention to detail, a careful study of the varied strains porcelain teeth are subjected to during the process of constructing a denture and thereafter, should be brought to bear in selecting teeth for each individual case. The artistic and the mechanical requirements are equally important, and it is important to know the resources of good workmanship in securing the best result when either one must be sacrificed. The large number of porcelain tooth makers, the individual peculiarities and the variety of their products, are decided helps in obtaining that which is best for each case. This suggests the importance of keeping in touch with that which they have to offer in the important matter of selecting teeth.

THE ARRANGEMENT AND FITTING OF THE TEETH.

The arrangement and fitting of teeth to soldered metallic dentures requires much more care than does the same operation in the construction of cast or molded dentures. Accurate fitting of the tooth to the metal plate is demanded on the score of strength and of cleanliness. If the tooth does not rest solidly upon the plate the whole of the stress due to usage is borne by the platinum pins; at times this results in the pins being broken, or they may be stretched and so reduced in calibre that they draw out of the porcelain. When this occurs the fault is usually ascribed to careless heading of the pins by the manufacturer; the fact, however, that the pins in these cases fit the holes in the porcelain loosely, and that if seen before they have separated from the teeth are found so reduced in diameter that they freely move while still held by the head imbedded in the tooth is conclusive that the tooth maker is not in fault. While it is impossible to secure absolute contact between the plate and the tooth, every effort should be made to secure accurate adaptation, leaving as little space for the accumulation of offensive matter between the tooth and the plate as possible.

The artistic problems of tooth arrangement are very much the same with all kinds of dentures; the mechanical procedure, however, by which this is attained, and the special mechanical problems involved are varied. It is to the latter, the special requirements of tooth arrangement for soldered dentures, that attention is now directed.

Entire Dentures.—To properly adapt, arrange to the best advantage, and to correctly finish a full denture of gum-plate teeth is one of the most difficult operations in prosthetic dentistry. Each tooth must be separately adjusted and fitted in position so as to secure the proper position and spacing of the tooth-part and at the same time properly contour the gum portion without breaks or offsets; to do this and to provide against accidents in soldering, and to accurately fit the teeth to the plate, tests to the utmost the workman's skill. To describe how this is to be accomplished, beyond indicating the proper use of the mechanical means employed, is equally a difficult task. It must be borne in mind that in plate work, teeth are fitted by grinding from their substance; nothing can be added to replace that which has been needlessly removed. This will suggest the importance of first fixing, definitely, the position of each tooth as nearly as can be done, by roughly arranging a series of teeth approximately in position; then to proceed carefully, making such corrections as may be needed in slant, length, fulness, and spacing; finally finish the joints between the teeth and make the gum portion form an even surface. There are three points to be first determined when making this preliminary arrangement; first, and first in importance, the median line. This should be accurately marked when taking the articulation while the plates are in the mouth, and should coincide with the median line of the face. To correct any error in its position, however slight, may involve changing the position of every

tooth upon the denture, and if this is done after the teeth have been accurately arranged, it will, in many cases, impair beyond remedy the adaptation of the teeth to the plate. A tooth accurately fitted in one position can seldom be as accurately fitted to another. If there is any doubt about the median line being accurately marked upon the model, hold the case so that a line drawn through the centre antero-posteriorly is exactly perpendicular: if the central teeth are in their proper positions, the bicuspids will be directly opposite to each other. There are occasional exceptions to this rule, but it is so generally reliable that it is well to regard with suspicion any centre mark that does not conform to it, and to ascertain beyond doubt its correctness before so far grinding the teeth, that their position cannot be changed without injury. The two other points are the junctions of the canines and bicuspids of each side. This point marks, first, the change in contour line of the denture from the anterior arch to its abutments, the posterior teeth, which are from this point arranged in a straight line; and second, a change in the slant of the teeth, from a marked leaning toward the median line of the anterior teeth to the nearly perpendicular position of the bicuspids and molars. It also determines accurately, the space to be occupied by the six anterior teeth. This joint, that between the canine and bicuspid teeth, is, in gum plate teeth, by far the most difficult to make of any in the denture, the artistic blending of the gums of the anterior and posterior teeth depends upon the workman's skill, whereas in gum block sections it is provided for by the tooth maker.

The first step in arranging a set of plate teeth is to clean thoroughly the platinum pins, especially to remove from them a slight coating of porcelain acquired when the teeth are made, being careful that this is done close up to the body of the tooth, where a little cone of porcelain is frequently found encircling the base of the pin. See, also, that the pins are straight, at right angles to the tooth, and parallel to each other. This can be done at this stage better than later, as it not unfrequently happens that a tooth may be ground away so close to a pin that while its hold in the porcelain is not materially weakened, a slight strain upon it might break it out and ruin the tooth.

If the wax or modelling composition used in taking the articulation has been carefully carved to represent the desired length and fulness of the upper and lower denture, that on the lower plate may be used as a guide in the preliminary arrangement of the upper teeth, the wax, or composition, for the time being taking the place of the lower denture. The upper teeth are usually arranged first, as they are more important in giving expression. Now, arrange upon the upper plate a layer of adhesive wax, not too massive, and yet sufficient in amount to hold the porcelain teeth securely when their pins are pressed into it. It is not desirable that this adhesive wax should be at all brittle, and yet it should be sufficiently hard to hold its form well, and to hold the teeth in position sufficiently firm when trying in the mouth, when with the wax spatula, it is fused around their pins. This layer of adhesive wax should extend nearly to, but not to touch the wax on the lower plate, and should

be molded to the general contour desired in the teeth, allowance being made for their thickness.

On this layer of wax arrange the eight anterior teeth, first placing in position the central incisors, grinding them sufficiently only to get them approximately in position. These are followed by the lateral incisors, the canines, and the first bicuspids; by arranging the teeth in pairs when placing them roughly in position, and also when adjusting them finally, one has a better idea of the general effect. During this part of the work, accuracy in making the articulating model will be appreciated. If an articulator is used, it is important that the centre line of the articulator and the centre line of the denture coincide; and also that the occlusal line and the top and bottom of the articulator are all parallel. In order to see that the teeth have a proper slant, and that the occlusal line gives to the teeth of each side the right length, the workman holds the articulating model before him on a level with the eye, and the eye is instinctively guided in judging of these matters by the upper and lower lines of the articulator. If the denture has been misplaced in the articulator, or the articulating model is defective in these respects, it is best to correct the fault as far as it can be corrected before proceeding. With these eight teeth roughly in position, and the place the canine tooth should occupy noted, the amount of joint-grinding necessary to bring the artificial teeth to their correct anatomical position is readily determined. This amount is to be divided among the five joints. In this preliminary arrangement let the teeth be a trifle too long to allow for a slight shortening when they are accurately fitted to the plate. Note carefully the surface of that portion of the plate upon which the teeth and artificial gums rest. If this is markedly uneven, but little grinding should be done until the spacing is well advanced. If a tooth is hollowed out to fit over a prominence, and is afterward moved forward, it is quite likely that the hollowed out portion will remain a vacant space. Note also that nearly all single gum plate teeth have the sides of the gum portion slightly rounded; the object of this is to provide a means for making the gums even when the teeth are fitted to an irregular surface, or when the tooth portion is arranged slightly unevenly. When it is desired that a tooth should set in more than its neighbor, this can be accomplished without making a noticeable offset by grinding more from the side of its gum when spacing. Advantage is taken of this in making the joint between the canine and bicuspid; quite frequently it is necessary to grind no more from the canine gum than to make the edge smooth, removing all that is necessary to close properly the joint from the bicuspid gum in order to place the bicuspid in its normal position, that is, slightly less prominent than the canine. And again, to bring the tooth portion of these two teeth into proper relation, it is not unfrequently necessary in order to make the gums blend, to make the joint at a slight angle, instead of in line with the axis of the teeth.

When these eight teeth are roughly fitted into position, the wax guide is removed from the lower plate, and the anterior eight lower teeth are

in like manner roughly fitted in place. If the upper and lower teeth are of proper width, and properly spaced, the points of the upper canines will rest between the points of the lower canines and first bicuspids. They should be made to take this position during this rough fitting while spacing the teeth. Up to this stage the teeth will usually retain their position sufficiently well by simply pressing their pins into the wax; some little care is required, however, to prevent the central incisors from being pushed from the median line, and to avoid displacing the upper teeth outward while arranging the lower teeth.

When the eight anterior teeth on the upper and lower plate are of exactly the right length; the overbite as it is intended to be; the curve of the arch, the fulness, so far as the tooth portion is concerned; and the general expression quite satisfactory, they may be, for the time being, considered finished. The gum portion, especially of the upper denture, may be a little too prominent, and the spaces a trifle too wide; it is well that they should be, to permit a final and more accurate adaptation of the gum portion to the plate, and a consequent closing of the spaces. The six anterior teeth of each denture are now firmly "waxed" in position so that they will not be disturbed while the posterior teeth are being arranged. This is done by passing a heated wax spatula on each side of the pins over each tooth, beginning with the centrals. This spatula should be sufficiently hot to melt thoroughly the wax and heat slightly the pins and the surface of the teeth; the teeth being held in place while this is being done by curving the fore finger of the left hand around them. The spatula is first passed between the centrals, and held until the wax is thoroughly melted, when it is withdrawn, the denture in the meantime being so held that the wax will not flow from its position. When this wax has chilled, the same procedure is repeated between the centrals and laterals, and between the laterals and canines; in each case the wax must be allowed to chill before proceeding, otherwise the teeth would become displaced.

The lower posterior teeth of each side are now roughly fitted, and then the upper bicuspids and molars, with especial care to make them normally articulate by proper spacing. The usual form of the gum portion of plate bicuspids and molars tends to make them assume an inward curve owing to the lingual side being made narrower so as to save grinding in making the joints. This must be guarded against. When the posterior teeth of each side are satisfactorily arranged, they are to be "waxed" firmly in place as were the front teeth, and it is well at this stage to adjust them in the mouth. Little changes may be needed that can now readily be made without detriment that if attempted after the final adjustment might result in imperfect joints. Prior to this, the teeth should be securely waxed; more wax being added where needed and the whole made neat and smooth. A little wax run in along the ends of the gums at the outer edge of the plate assists very much in holding them securely. There is always a risk that the patient may, inadvertently, close a little too firmly; this will displace them if the cementing with wax is not thoroughly done.

After making any corrections suggested while trying the teeth in the mouth, they should be carefully gone over and the final fitting of the teeth to the plate, evening of the gums, and accurate adjustment of the joints receive needed attention.

The arrangement of the teeth is now complete.

Arrangement and Fitting of Teeth to an Upper or Lower Denture.—In arranging the teeth to an upper or lower denture, the same general plan is followed as in arranging a full denture. If the antagonizing teeth are markedly irregular, some little ingenuity may be required when fitting gum teeth to make the occlusal edges of the anterior artificial and natural teeth fit sufficiently close to prevent lisping, or to prevent a hissing sound when pronouncing certain letters, and at the same time preserve a desired alignment of the artificial teeth and gums. This is more readily accomplished when plain teeth are used as it is not complicated by the artificial gums. Nevertheless, much care is required in these cases to make plain teeth fit solidly upon the plate. The same precautions are required; the teeth must first be approximately adjusted to position, the grinding cautiously done, and the final accurate fitting deferred until the position of the teeth has been definitely determined. The anterior lower teeth, on account of their narrowness are more readily fitted; they are less concerned in expression, and the artistic requirements are less exacting.

Gum and Plain Teeth.—Whether to use gum or plain teeth in constructing soldered plate work is decided by the same general rules applicable to all dentures. Gum teeth are required to restore a normal fulness, or to hide the plate. In some cases where gum teeth are required, and where it is desired to have as little fulness as possible, the gum teeth may be set directly upon the natural gum, the plate being cut away to allow them to do so. It is seldom necessary to cut it away further back than the canine teeth. The plate should be allowed to extend as far under the teeth as possible, the edge of the plate being beveled quite thin so that after the teeth are soldered it can be burnished up to them and a close joint made. It is a common fault to cut the plate away too much, not only depriving the teeth of the support it should give, but impairing the adhesion and bringing the edge so directly under the solder that it is too rigid to burnish up to the teeth. To avoid this, if the teeth have been recently extracted and the alveolar border is quite uneven, it is allowable to trim down the more prominent portions; even in cases where resorption is well advanced, the portion of the model against which the artificial teeth fit may be somewhat freely carved or rubbed down with fine sand-paper. It is desirable that in the mouth the artificial gum should fit closely the natural gum; inasmuch as the wax does not usually hold the teeth quite close to the model, and since there is tendency for the teeth to move out slightly during soldering, teeth fitted to a model thus carved will fit in the mouth more satisfactorily than if it were not done. The teeth are now fitted to the model without the plate sufficiently to determine accurately the position they should occupy. This done, cut away the plate nearly, but not quite as much as will be

required, and after beveling the edge, make the edge fit very close to the model, even sinking it slightly into the plaster, and proceed to fit the teeth in position with the plate in place. As the work proceeds more may be removed from the plate as it is seen to be necessary. By thus proceeding, and by carefully fitting the teeth to the plate, using for this purpose very small grindstones, the teeth will be well supported by the plate, and the joint between the plate and the artificial gum, after the edge of the plate has been burnished close to the porcelain will be cleanly, smooth, and non-irritating to the tissues against which it will rest when the finished denture is in use.

Cases are met with where an artificial gum is required on account of resorption of the alveolar border, and where the upper lip is so short that the edge of the plate is liable to show above the gums of the teeth. In these cases the plate is cut away so that the gums of the artificial teeth will just cover it, and the teeth are so fitted that the edges of their gums rest upon the natural gums. In such cases the edge of the plate is not beveled, but made square. The plate is cut away only sufficiently to allow the artificial gum to extend from one-sixteenth to one-eighth of an inch beyond, a groove is then cut in the model just beyond the plate-line a full thirty-second of an inch deep, as far as the artificial gum is to rest upon the natural gum. This facilitates an accurate fitting of the artificial gum to the edge of the plate, and ensures a close fit of the artificial gum to the natural gum. If too much is removed from the model, and in consequence when the denture is finished the artificial gum presses too hard upon the natural gum, this is readily corrected by the careful use of a small grind-stone, whereas if it does not fit closely enough the fault is without remedy.

Plain Teeth.—Plain teeth are more readily arranged than gum teeth. Where conditions favor them, they make a stronger and more cleanly denture. It is exceptional, however, when they can be used on a denture where the plate extends over the alveolar border. Cases are now and again, met with, however, where the lips are long and the tips of the teeth are alone seen, and where the teeth themselves will impart sufficient fulness; in these plain teeth may be used with decided advantage. The differences in the technique of their arrangement from that of gum teeth in full, and in full upper and lower dentures is self-suggestive. It is quite as important, and the same care is required, although less labor is involved, to make them fit accurately to the plate on acount of cleanliness and strength.

Plain teeth are especially called for when a denture is made soon after natural teeth have been extracted, or where the alveolar border is broad and the teeth are set upon or into the natural gum. In some cases the four, six, or eight, anterior teeth are so set, the teeth further back being set upon the plate; in some cases, indeed, on account of resorption of the posterior portion of the alveolar border, plain teeth may be used in front and gum teeth at the back. The decision to use plain teeth set upon the natural gum for the front portion of the denture is usually reached when marking out the plate line, and the plate made accord-

ingly. It should, however, be made to extend over the alveolar border a little more than seems necessary, as, until the teeth are partly arranged it is impossible to know exactly where it should end. It is very desirable that the plate should extend under the teeth as far as it may, and yet be well covered. In order to ascertain how to trim the plate, first arrange the teeth to the model without the plate; while so doing carve the model so that the teeth will press hard into the gum. How freely this should be done depends very much upon the condition of the gums themselves. If the teeth have been recently extracted, or if the gums are quite soft and yielding, the model may be carved quite freely; if on the contrary they are hard, it must be done more cautiously. This however, may be remembered; the gums usually yield under pressure, even when the pressure is very slight, there is usually a shrinkage of the gum tissue shortly after a denture is inserted. When first inserted a tooth may fit upon the gum quite neatly; a few weeks later, on account of this shrinkage, it may not touch the gum at all. If the pressure is too great the fault is quickly remedied by a touch of the grind-stone. The beauty of plain teeth adjusted to the natural gum consists in so arranging them that they appear to be growing out of the gum. Having determined to what extent the teeth should press into the natural gum and the position of the two central incisors, form a groove of the desired depth, its lingual side sloping and its labial side quite perpendicular, into which the teeth are to be fitted. This groove is to be extended as the laterals, canines, etc., are fitted into place. A groove is preferable to bodily cutting out a seat for the teeth, as it readily permits a sidewise change of position, and shows at all times how far the teeth extend beneath the surface of the model. When as many of the teeth as are to set upon the gum are in place and cemented upon the model, with a fine needle-point make a traced line upon the model around their necks, thus marking the exact position of each tooth. Remove the teeth, and cut the plate so that the edge shall be about one-sixteenth of an inch within the line, not following the festoons, however, but making the edge straight and well beveled. The triangular portion of plate between the teeth can be readily and neatly cut away with a fine file when finishing the case. Then replace the teeth, grinding them to fit over the plate. Usually the last tooth of the series resting upon the natural gum will be the first or second bicuspid, depending partly upon the condition of the alveolar border as regards resorption, and partly upon how far the plate is visible at the angles of the mouth. As a rule this last tooth rests partly upon the gum and partly upon the plate; it should be so set as to hide as much as possible of the plate beyond it. In grinding plain teeth a much smaller stone is required than for grinding gum teeth.

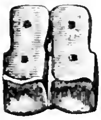
Plain teeth are more liable to be displaced when trying them in the mouth than are gum teeth; on that account they should be more carefully cemented to the plate.

The technique of fitting teeth of partial soldered dentures differs but slightly from that of fitting teeth of any form of partial dentures beyond the fact that in one case the plate is fitted to the teeth after the teeth have

been fitted into place, and in the other they are themselves fitted to the plate. Further than this the mechanical and artistic requirements are very much the same, and are elsewhere in this work given in detail.

General Suggestions.—Corundum, or carborundum wheels of coarse grit, three-sixteenths of an inch thick by one and one-fourth inch in diameter, having a round edge, are used for the rough grinding. For the final grinding smaller wheels of a finer grit are required. For joining, some prefer a rather large wheel, and use the side instead of the edge; others a wheel about one and one-half inch in diameter, and about one-fourth of an inch thick, of fine grit, and with a square edge, kept especially for this purpose, and use it by holding the tooth between the thumbs and index fingers of both hands, pass the joint rapidly across the edge of the wheel backward and forward. It is best to be provided with wheels suitably for side or edge use, and not to confine one's self to either method, but to practice both. It is very important to make the joints in such a manner that the joint surfaces are in contact throughout, as shown in Fig. 550. Great care must be exercised that there be no V-shaped space at the back of the joint (Fig. 549): not only is such a faulty joint uncleanly, but with close contact of the pink borders anteriorly the gum will almost inevitably flake when the teeth expand by heat during the process of soldering.

FIG. 549



Lingual aspect of a faulty gum-joint, in contact on the labial side only.

FIG. 550

Lingual aspect of a properly made gum-joint between two upper central teeth, in contact throughout.

The bases of all the teeth should rest solidly upon the plate (Fig. 551, A), thus bringing the strain upon the bodies of the teeth, and not upon the pins (Fig. 551, B), as occurs when the teeth are imperfectly fitted.

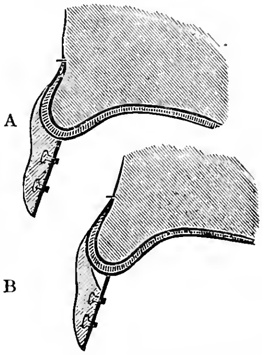
When fitting teeth to the natural gum it is well to remember that this portion of the model, especially the labial surface of the gum and that portion immediately adjoining the remaining natural teeth, is apt to be reproduced a trifle larger on the model than it is in the mouth, even though the model is from an otherwise faultless impression. This may be due to "creeping," when wax, or the so-called "impression compounds" are used, that is, a slight change of form after the impression has been pressed into place and before the material has been chilled sufficiently to make its form permanent. When plaster is used, it may be due to the sluggish manner in which the plaster flows through the interspaces, or to neglect in pressing the plaster to the gum, or the plaster may be drawn away from the gums by the lips before it has set, or in removing the impression this portion may break in such a manner as to prevent accurate replacement. The defect frequently occurs, and while it is generally slight, it is sufficient to make a decided misfit between the natural and artificial gum. This may be corrected by carving this portion of the model before fitting the teeth.

Accurate adjustment of the teeth to the plate may in many cases be facilitated, especially in partial cases and with teeth that stand alone by flattening the surface of the plate upon which the teeth rest with a

flat file; the amount removed may be trifling, and yet it may make a surface much easier to fit.

Pigments of various kinds have been suggested to indicate the point of contact between a tooth, and the plate or cast, which must be ground away in adjusting a tooth in position. Thin carbon paper cut so as to lay evenly against the plate, has been recommended; the tooth pressed against this will be marked at the point of contact. Rouge, made into a paste with oil; a black or blue crayon, or a blue pencil, may be used to color the surface against which the tooth is to fit. They may be helpful to some; a skilled workman, however, seldom makes use of them. A cultivated sense of touch enables one to know with remarkable accuracy the exact point to which the grind-stone should be applied. A slight rubbing motion makes a white spot upon the tooth where it touches the plaster, and a distinctly discernible mark where it impinges upon either gold or silver, provided the metal is not coated with wax. These marks will continue to be made. Pigments must be constantly renewed or they are deceptive, and most of them are unpleasant to use, they smear and soil the work and the workman's hands.

Fig. 551



A. A gum tooth, accurately fitted to, and resting upon the plate

B. A gum tooth imperfectly fitted to the plate.

TRYING THE TEETH IN THE MOUTH.

In full upper or lower or entire dentures the points to be carefully considered when trying the teeth in the mouth are—first, the accuracy of the articulating model; if that is correct the teeth should articulate in the mouth very nearly as they do upon it; second, whether the joint between tne central incisors is in an imaginary line bisecting the face; third, whether they are of a proper length, and in the case of an entire denture, whether the relative length of the upper and lower teeth is as it should be; fourth, whether they have the proper slant and relative length, one with the other; the upper teeth should slant toward the mesial line, and in a young person the centrals should be a trifle longer than the laterals, for persons advanced in age, the length of all the incisors should be the same; the lower incisor teeth should be of the same length, and slant but little if at all; fifth, the fulness, that is, whether the normal lip outline is restored; and sixth, the expression and the changes in expression and in articulation due to the movements of the mouth and adjacent parts, and their general harmony.

Inasmuch as nearly all changes in soldered plate work must be made with the grind stone, and that any portion of a tooth once removed cannot be restored, it is a wise precaution when constructing full, or

nearly full dentures, to make a preliminary trial of the teeth in the mouth when they are partly arranged. It is a satisfaction to know that the models are correct, and to have a general idea of how the teeth should be when accurately adjusting them to position. Trifling changes in the articulation noted as needed when trying the teeth in the mouth, changes that it is seen can be readily made with the grindstone, may be left until the denture is finished; some changes that may seem necessary at this time may not be needed when the patient can close the mouth firmly without danger of displacing the teeth from the plate.

If the articulating model is correct, required changes in length, slant, or fulness may be indicated by moving the teeth concerned into new positions until the desired effect is produced, making no attempt, however, to refit them until a satisfactory rearrangement has been effected. If these changes are at all extensive, it is best to try the denture again in the mouth after they have been made.

If the articulating model should prove defective, or the teeth be found too long or too short, it is better to place a little soft wax between the teeth on each side of an entire denture or all around an upper or lower denture, and proceed to take a new articulation, allowing the teeth to remain upon the plate if they do not interfere, as their presence aids in the correction of the defects of the old articulation. Make also a new articulating model: this course is far more satisfactory than to attempt to alter the old one, and saves time in the end.

Trying partial cases in the mouth is frequently a difficult task, especially if the teeth are scattered. If a hard cement is used, it is necessarily brittle, and the teeth are broken from the plate with the slightest strain; if the cement is soft, they will move, and unless carefully watched and their position in the mouth compared with their position upon the model, the trying in will amount to but little. Quite frequently the teeth fit so tightly between the remaining natural teeth, or are placed at such an angle, that the plate cannot be removed from the mouth without displacing them. In these cases endeavor to judge what changes are necessary and adjust the teeth to the model after the plate is removed from the mouth. It is not always desirable to arrange the teeth so that they can be readily placed in the mouth while fastened on the plate with cement; it may be a decided advantage to make them fit too tightly for this. Or, again, the natural teeth may so lean that, although it is quite difficult to pass over them the plate with the teeth attached with cement, the finished case, with the teeth and plate firmly united with solder, will readily spring into place, and be held more securely and comfortably than if made to go into place easily. A well fitting partial denture may have to be manœuvered into place, one side being inserted first, or be twisted and turned to accomodate leaning or misplaced teeth, or it may require a little force to press it into position. This can seldom be done with the teeth secured to the plate with adhesive wax. In these cases the main purpose of trying in the teeth is to discover and correct inaccuracies of the model, to see that the teeth in size, shade, and character harmonize with the natural teeth, and

that the artificial teeth are in a position where they can be made to fill properly the spaces when they are firmly soldered to the plate. Cases now and again occur where, when the teeth are in their proper position, it is impossible to remove them and the plate from the model, and it becomes necessary to break off one or more of the plaster teeth in order to remove the case from the model without displacing them. It has been suggested that a case which cannot be removed from the model without mutilating it cannot be inserted in the mouth; it must be remembered that the plaster teeth of the model are very much more rigid than are the natural teeth in the mouth, and that they are not always accurate in shape. Such a case may require more or less "fitting," when it is finally inserted after finishing, but will, as a rule, prove more satisfactory fitted to the mouth than if it had been fitted to the model.

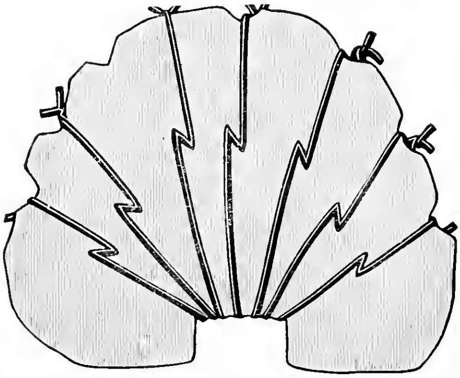
When satisfied with the arrangement of the teeth, before investing, see that they hold in place sufficiently firm that they will not be displaced when pressed into the investment. Teeth standing alone may require for additional security, a drop of wax underneath, at the point where the plate and porcelain meet; a little soft wax flowed inside long and weak gums may ward off an accident when the case is removed from the investment after soldering.

RIMMING.

The addition of a rim to dentures of single gum or block teeth—that is, a band of gold or silver upon the border or edge of either an upper or lower plate to receive the gum extremities of the teeth—adds very much to the strength and to the artistic appearace of the denture. It can be added only when the plate extends beyond the gums of the teeth, and when the lip is sufficiently long to prevent its being seen when the mouth is widely opened and the lips retracted, as in laughing, etc. Rims are not confined to full dentures; they may be applied to either upper or lower partial cases where there are a number of single gum or block teeth together. If the work is well done, rimming makes a neat finish to the denture ; the thick, smooth, rounded edge is more comfortable to the patient, and the rim, covering the joints between the plate and the teeth with its free edge burnished closely to the gum extremities of the teeth prevents the lodgement of food, etc., and thus adds very much to its cleanliness. Rimming also materially strengthens the denture, not only by the amount of gold or silver added to a weak part of the plate, but also by forming a groove or socket in which the ends of the teeth rest, protecting them from injury and assisting the platinum pins in resisting the strain of mastication, especially those of the molars and bicuspids. Rimming a plate before the teeth are fitted to it is a very simple matter. It is done immediately after the plate has been adjusted to the mouth, the articulation secured, and the articulating cast made. The wax used in taking the articulation, giving also the intended fulness of the gum, indicates the width of the rim. In locat-

ing the position of the rim two things are to be considered: first, the probability of the border of the plate extending too far over the alveolar ridge; and second, the probability of the rim being seen when the mouth is widely opened. Provision must be made for reducing the size of the plate without injury to the rim should its border press too firmly upon the soft tissues. To this end the rim is located a little inside the outer border of the plate, but not so far as to be exposed in laughing, etc.; and in soldering it to the plate the solder is allowed to run into and fill the apex of the angle between the rim and the plate. In constructing such a rim take a strip of plate sufficiently long, about No. 26 American Standard wire gauge (.01594 of an inch thick,)—the width of the intended rim. After cleaning the plate, adjust the strip at about the middle of its length so that one edge touches the plate at its median line and other stands out from it at an acute angle, forming a groove or socket into which the teeth are to be fitted. This may be

Fig. 552



Method of tightening wire in operation of "tying down."

held in place for soldering, with binding wire, with a wire clamp, or it may be held with adhesive wax and invested for soldering. Begin soldering by "tacking it"—that is, flowing a little solder so as to unite the rim and the plate a portion of the distance they have been fitted: the object is to unite them firmly at one point, so as to facilitate fitting the remaining portion of the rim. If the portion of rim soldered does not form a desirable angle with the plate, it may be bent with the pliers, in or out, until it does. Now proceed to fit the strip to the plate as far as it can be conveniently done, securing it in position with binding wire, and solder. Repeat this until the rim is fitted and soldered nearly as far as it is intended to go. As the exact position of the last molar cannot be determined at this stage, an ample length of the strip is left unsoldered, enough to continue the rim around the posterior of the last molar. This is to be fitted and soldered after the teeth are arranged in place. The rim is now neatly finished by being reduced with a file to a proper width, and the free edge slightly beveled. This

method of forming a rim may be used on either an upper or lower plate.

Of the many methods which have been from time to time suggested for rimming dentures of single gum teeth, after the teeth have been fitted, the following are selected as being simple and practicable.

For many years the writer invariably rimmed these cases after the teeth were soldered to the plate: in doing so there is a slight risk of shattering the gums during soldering, and of warping the plate, but with care in investing, in applying the borax, and in soldering, accidents seldom occur. It is done quickly, and with much less labor than by any other method; a rim so made is neat, strong, and effective. When this method is followed, after the case is soldered and cleaned by acid, and before commencing to finish the backings, carefully wash the denture to remove all trace of acid, and then grind the gum ends of the teeth until they conform to an even line from heel to heel of the plate, removing the rounded edge, and forming an even bevel of a somewhat obtuse angle to receive the rim. It is important that the finished rim should fit with absolute closeness to the teeth at its free edge; and, as it is more difficult to burnish it to a rounded surface than to a flat one, this should be borne in mind in preparing a denture for rimming.

It is important also to have sufficient room between the ends of the teeth and the edge of the plate, not only to solder the rim, but also to give the rim sufficient width to avoid making the edge too abrupt.

If the rim is narrow and of the same width from end to end, half-round wire, letting the flat side rest against the teeth, is usually to be preferred; if wide, or wide at some points and narrow at others, it is best to cut a paper pattern and make the rim of plate about No. 24 gauge (.0201 of an inch thick). Usually the rim of a lower denture is made in one piece, that for an upper denture is sometimes more conveniently made in two pieces, each extending from the mesial line to the tuberosities of either side, overlapping at the mesial line to make a neat joint.

When preparing to solder a case which is intended to be rimmed in this manner, a piece of plate should be fitted around the back part of each end molar, extending from the backing as far around the molar gum as it can be soldered, and soldered in place at the same time as the teeth are soldered to the plate. This is intended to form part of the rim, and is fitted and soldered at this time on account of the difficulty of reaching that part when the case is invested for soldering the other portions of the rim.

The method of fitting the rim is the same for either plate or half-rouud wire. Begin at the median line, and carefully bend the plate or half-round wire with either the fingers or pliers until it fits accurately in place, beveling each end so as to make a neat joint with the piece extending from the backings around the last molar at one end, or if made in two parts, with the other half of the rim at the median line. It is hardly probable that it can be fitted so accurately when invested in

place as not to spring somewhat, but it should so nearly fit that the iron binding wire used to hold it in position during soldering simply holds it in place, and is not depended upon to draw it close to the teeth. If the fitting is imperfectly done and the rim is drawn close to the teeth by the wire, it may seem to fit accurately when invested; but when the case is heated for soldering, the binding wire, becoming hot before the rim, will expand and allow the rim to spring from the teeth, so that after it is soldered it will be a difficult, if not an impossible task to bend or burnish it to fit as closely to the teeth as it should. After the rim is fitted as accurately as possible, it may be held in place for investing with adhesive wax, or preferably with iron binding wire. For this purpose annealed iron wire No. 30 or 32 may be used; strength is of small importance; there should be but little strain upon it. Before placing the rim in position, paint the porcelain against which it is to rest with a thin coating of whiting and water or plaster and water, letting it run in between the gums of the teeth and the plate, but carefully keeping it from any part upon which the solder is intended to flow. This is mainly to prevent the borax from coming in contact with the porcelain.

Adjust the rim in place, and pass a wire around the case in such a position as to impinge upon the rim on both sides—say between the bicuspids or the bicuspid and molar—passing it between the teeth or over the occlusal surface as may be most convenient; twisting the ends together so as barely to draw it tight enough to hold the rim in place; then, taking hold of the wire with the flat pliers, draw it sufficiently tight by bending it upon itself. If the tightening is done entirely by twisting the ends, there is a great risk of changing the shape of the plate either while placing the wires in position or during soldering; by bending the wires as suggested sufficient strain is exerted to hold the rim securely, without the slighest risk of bending the plate; the wire, so bent, is not a rigid band around the case, but exerts an elastic pressure. Place as many wires around the case, in any direction most convenient, as may be necessary to hold the rim securely. If half-round wire is used for the rim, it should be wide enough on the flat side to reach from the plate sufficiently far over the gums of the teeth to cover the bevel made with the grindstone, but not to extend beyond this. Where it passes over slight depressions in the plate, do not bend the wire to fit them, but depend upon fitting a piece of plate to fill the vacancy.

When the rim is accurately adjusted and held in place with adhesive wax or with wire, proceed to invest the case for soldering, using for this purpose a mixture of plaster and sand precisely the same as is used for investing to solder the teeth to the plate. First fill the lingual surface of the denture with the investing material to a level with the tops of the teeth then invert it over a mass of investment previously placed upon a piece of glass, pressing it down so as to leave about one-quarter of an inch under the cutting edges of the teeth; then build it up outside of the teeth about one-half of an inch thick, high enough to protect thoroughly the gums and

to extend a trifle over the free edge of the rim: build the batter up quite wide at the top, so that there will be no danger of its cracking, so as to expose the gums of the teeth. Build it up at the back part so that the posterior edge of the plate is well covered, and extend it over the palatal surface to a little beyond the margin of the vacuum-cavity, so shaping it, however, so as to permit soldering the rim far enough around the last molar of each side to meet the piece extending from the backings.

When the investment has set proceed to solder the rim. If binding wire has been used, do not disturb it. Apply borax carefully and not too freely, add sufficient solder to "tack" the rim at a number of points, and proceed to heat the case preparatory to soldering. When using the blowpipe to flow the solder, avoid directing the pointed flame against that part of the plate immediately back of the gums of the teeth. Endeavor to heat the case evenly, and after fixing the rim in position by fusing or flowing the solder first placed, cut or break those strands of binding wire not fused or burned in two, and carefully bend their ends out of the way, taking especial care not to disturb the investment. Any portions of binding wire held by the solder or borax, and not readily removable, may be allowed to rest until completing the soldering when, if in the way, it may be pushed aside with the soldering-point. Then begin at one end of the rim and reflow the solder, adding enough more to fill the sharp angle between the rim and the plate and to permit a smooth, neat finish.

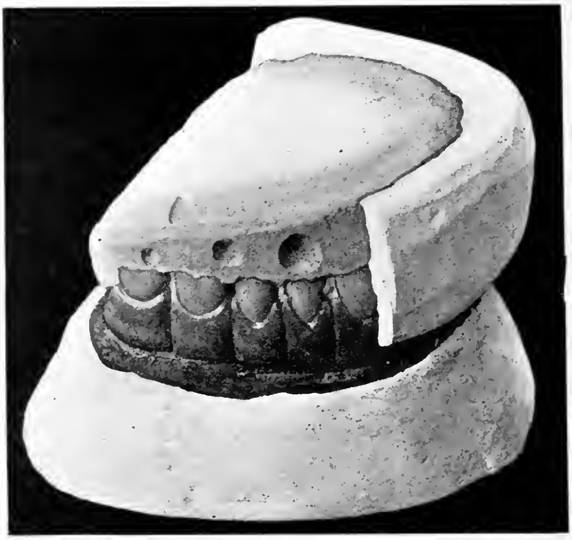
This method of rimming is more rapid than any other, and has the decided advantage that after the teeth have been adjusted to the mouth and finally fitted they are not again removed from the plate. It requires careful attention to detail to avoid fracturing the teeth or warping the plate, but in careful hands it is by no means as hazardous as might be supposed. The description refers to a full upper denture, but the method may be used equally well for rimming partial or lower dentures, the changes needed when it is a applied to these will readily suggest themselves.

To rim a denture after the teeth have been finally fitted to the plate and before they are soldered in position, proceed as follows:—

Place the denture fully prepared for investing upon the plaster model, having previously made one or more cone-shaped holes, or a vertical groove, in the back part to serve as guides to readjust to the model the model now to be made; and after varnishing the surface of the model so that plaster now to be added will not unite with it, proceed to build plaster upon the model precisely as though making an articulating model, allowing it to extend above the teeth and just to the outer edge of their occlusal surface and over the back part of the model, so as to have a solid bearing. When this is hard, smooth the edge immediately over the teeth, making around it a number of cone-shaped pits, and after properly preparing the surface of the plaster to prevent union, add plaster so as to extend over the surface of the teeth as far as the gums, and to extend over the plaster model previously made sufficiently far to give it a solid bear-

ing. (Fig. 553.) The object is to imbed the teeth thoroughly in plaster, so that in fitting the rim they can be removed from the plate, and readjusted as though they were one piece. This guide is made in two sections, so that if desired when the rim is finished the last-made section may be removed without disturbing the relation of the teeth, to permit of the denture being invested in the manner presently to be described. This plaster, when set, will hold the teeth securely and the denture may be removed from the cast and the gum ends of the teeth ground even and

Fig. 553



Guide to hold single gum teeth together while adjusting a rim, a portion broken away to show its construction. This guide is made in two parts, the first rests upon the cast and fills the inner portion of the denture, extending over the teeth and just to the outer edge of their occlusal surface. The second part fits onto the first part, and extends over the teeth to near the extreme ends of their gums. The two parts hold the teeth together so that they can be removed from the plate and handled during the fitting of the rim as one body; they are not separated until the rim is quite finished and the denture ready to be invested for soldering.

to a bevel precisely as described for rimming after soldering the teeth to the plate.

The rim may be fitted to the teeth by swaging, making the die for each half of the rim by molding in sand directly from the denture; or by taking a plaster impression of the parts to which the rim is to be fitted, and from this making a plaster model to be reproduced in zinc by the usual method; or by taking this impression in a mixture of molding sand and plaster or other impression material into which zinc can be cast. After the zinc die is made a lead counter-die is obtained in the usual manner. Then, cut a paper pattern by which to cut the metal strip of which the rim is to be made. Swaged rims should be made to extend to the border of the plate; thus made, they are much easier to swage and to solder and make a neater finish. There is usually a little difficulty in

holding the strip in place upon the die when commencing to swage, and a constant liability of its moving out of position during that operation unless great care is used.

After the rim is swaged and fitted to its position, the two halves being slightly beveled and overlapping at the median line, so as to make a neat joint, and that part extending around the last molar of such side adapted to make a continuous band to and uniting with the backings, it may be held in place for investing by shellac, or by a little plaster placed at several points, or by drilling several rivet holes and riveting it in place. This latter method is by far the most secure and is readily done if there is room between the gums and the edge of the plate for the rivets. The rivets are to be placed in the holes and tightened before the teeth are removed from the plate, so that there will be no risk of the rim changing its position during investment and soldering. Then slightly warm the plate by holding it over a Bunsen burner or a spirit lamp and remove the plate, leaving the teeth imbedded in the plaster molds. The plate and rim are removed from the teeth for investment in the same way if the rim is held by shellac or plaster: it must be done, however, very carefully.

The plate with the rim is now invested in a mixture of plaster and sand such as is used for investing teeth. If the rim is very narrow and does not extend much over the plate above the teeth, it should be, before investing, painted on the inside with whiting or plaster to keep the solder from filling it up; in other cases, it is better that the solder should run in slightly, so that there will be no danger of filing through if it should be found necessary to reduce the size of the plate: a little care in soldering will prevent the solder filling the socket so as to interfere with the teeth.

By a second method, place the denture fully prepared for the reception of the rim on the model and proceed to make a plaster impression of the parts to which the rim is to be fitted, allowing the impression to extend around the last molar as far as the rim is to go, and to rest upon the front part of the model sufficiently to permit of its removal and accurate replacement, the model having been previously prepared to prevent the new plaster from uniting with the old. When the impression has set, remove it by inserting a thin knife-blade between the new and old plaster; it is seldom that its shape will permit its removal in one piece, but with a little care it can generally be broken away in but few pieces. Then remove the denture, and after warming the plate remove it, leaving the teeth imbedded in the guides. Clean the adherent wax from the plate, and after replacing it upon the model replace the impression, securing it in position with adhesive wax; oil, or otherwise prepare the impression so that new plaster will not unite with it, and proceed to run plaster mixed with pumice stone or marble dust so as to be non-shrinking when heated into it, in order to secure a fac-simile of that part of the teeth to which the rim is to be fitted, allowing the plaster to extend over the lingual surface of the plate so as to give the cast sufficient strength. Any of the prepared investment materials

may be used in place of plaster. When this has set, remove the impression. Now proceed to adjust a rim to this fac-simile of the teeth in precisely the same manner as though it was the teeth soldered to the plate, holding it in place with binding wire precisely as directed when describing that method, taking especial care, however, not to draw the wire so tightly as to crush the plaster. The rim is soldered without investing. Success by this method depends upon careful manipulation, and upon securing an accurate fac-simile of the teeth in a material making a smooth, sharp model, and one not readily abraded, and that does not shrink when heated to the fusing point of the solder used.

By the third method the rim is fitted to the teeth themselves, as is a swaged rim, and held in place with shellac or plaster while the teeth imbedded in the mold are removed from the plate. The plate and rim are then invested, the investment being molded to extend slightly over the free edge of the rim to hold it in place. It is seldom necessary to place whiting or plaster inside the rim to keep the solder from entering; the investment usually prevents its encroaching upon the space required for the teeth.

The writer prefers this latter method. It is simple, less labor, and as the rim is fitted to the teeth, errors of adaptation owing to a model being abraded or broken are avoided. When time is no object, and the workman not accustomed to fitting rims, or for special cases, swaging gives good results. Theoretically, it should give more accurate results than any other method, but practically there are so many difficulties encountered in constructing the dies, in keeping the strips of metal between them, in so arranging that the impact of the blow will swage the rim evenly, that it is seldom practised by practical workmen.

It is a mistake to make a rim of very thin metal. Gold should not be less than No. 26, while silver should be a little heavier. The thicker metal holds its position better during soldering; its free edge is readily thinned with a file as may be found necessary when burnishing it close to the tooth gums, and is not so liable to stretch under the burnisher. Where it can be used, half-round wire has decided advantages. It is readily bent in any direction, and has thickness where thickness is most desirable; it requires, however, owing to its rounded edge, the free use of solder or the addition of narrow strips of plate to avoid an objectionable groove at its junction with the plate.

The investment has but a slight hold on the rim, this will suggest care in preparing for soldering, and care during that operation to prevent its displacement. It is usually best to heat up invested rims slowly and to heat them as hot as one would for soldering teeth; otherwise when the hot blowpipe-flame strikes the narrow rim it is suddenly expanded and curves up; making a displacement difficult to contend with when finishing the denture. Care should also be exercised to avoid fusing the rim, an accident very difficult to repair; or allowing the solder to flow over it, especially near its free edge. Small pieces of solder should be placed at intervals, and these should be first fused tacking the rim to the plate quickly. This accomplished, begin at one end and flow

the solder in sufficient amount to make a joint that will finish up neatly; where much filling in is needed, narrow strips of plate may be added.

After the rim is soldered and the plate cleansed with acid, place it on the model to see that it fits as accurately as it did before—it is seldom that there is any material change if the work has been carefully done; then proceed to adjust the rim and to finish it as far as is desirable to do before the case is invested.

As it is difficult to get a smooth, even edge to a rim after the teeth are soldered to the plate, the rim edge should now be finished, using for the purpose a dead-smooth file and very fine emery or sand-paper. Do not bevel the edge too much; it should be rounded rather than beveled from the labial side, and left thick; it will be somewhat further reduced when it is burnished close to the teeth in finally finishing the case, and if made too thin it is apt to tear and break during that operation.

The next step is to readjust and secure the teeth to the plate for investment; the procedure for doing this is the same, no matter by what method the rim has been constructed. Naturally, one would think that this could be accomplished by simply heating the plate so that it would soften the adhesive wax, placing it upon the model, and then press the guides, in which the teeth are imbedded, firmly in place. If the rim has been swaged and riveted to the plate before the teeth were removed, this will often give accurate results; in other cases, however, it is very uncertain. There is a tendency in the rim to creep bodily toward the alveolar ridge during soldering, so that when the teeth are placed in it after soldering they are a trifle too long, not enough to affect seriously the articulation, but enough to prevent their fitting solidly to the plate.

Wax, particles of plaster, slight changes in the form of the plate, etc., may prevent the guides fitting exactly as they originally did. In order to ensure accuracy in this respect, before removing the guides from the model make a slight cone-shaped depression in the guide and another immediately below it in the model at about the median line; into these adjust the point of a pair of dividers, and accurately measure and note, or mark their distance apart on some portion of the model, so that the dividers can be again set in the same position. It is only necessary to apply the dividers again to these points to determine when the guide is in its original position. In many cases it is necessary to remove a portion of the wax and to cut the plaster away from the guide so as to free the plate entirely before it will fit in its original position, not disturbing, however, that portion which rests upon the back part of the model. Occasionally it is necessary to grind the ends of the gums; this should be done carefully, and not until it is found absolutely necessary; usually a little taken from the plate side of their extreme ends will be sufficient. This can generally be done without removing the teeth from the guide. If the teeth are kept together and not removed from the guide, one may depend upon accurately replacing them; if they are removed, it is very difficult to replace them without some slight changes in their position.

After the teeth are accurately fitted to the rim, so that the guide with the teeth imbedded in it will go on the model in its original position,

secure the plate to the teeth with adhesive wax and remove the plate and teeth thus held together from the model, and add a coating of investing material to cover the rim and exposed ends of the teeth, letting it extend under the plate. When this has set, remove the outer portion of the guides, that portion which covers the face of the teeth and which was made so as to be removable; cut from the remaining portion so as to expose one-third of the grinding surfaces of the molars and bicuspids, and add a fresh portion of investment, allowing it to cover all exposed portions of the teeth and to overlap the portion first added, wetting this with water so that the two will unite. When this has set, carefully remove the remaining portion of the guide, heating the plate to soften the wax and permit its removal. If any teeth are disturbed during this operation, they should be replaced and made secure. After wrapping this preliminary investment with binding wire as a precaution against the investment cracking, the investment of the denture is completed in the

Fig. 554

Upper denture rimmed.

usual manner. If this procedure has been carefully carried out, there will be no material change in the position of the teeth, and much less time will have been occupied than if the teeth had been separately adjusted to position, with the further advantage that the even gum line made as the first step toward the construction of the rim will have been preserved throughout. The changes in technique for rimming a full upper or lower or a partial upper or lower denture are so slight that further description is unnecessary.

After the teeth are soldered, the first step toward finishing the rim is to make its free edge fit closely to the gums of the teeth; this is accomplished by the use of the burnisher and the file—the burnisher to bend the edge, and the file to thin the edge when it is too thick for the burnisher to bend it. This accomplished, by the use of suitable tools the rim is to be given smooth and even surface. The finished rim is shown in Fig. 554.

The operation of burnishing, when the object is to change the shape of a piece of metal, is analogous to "metal-spinning," and is very different from burnishing to produce a hardened polished surface; in the first the burnisher is used with considerable pressure, its motion is slow and deliberate, so as to effect the desired change before the metal has lost the softening effect of annealing and become hard and elastic. In the second

the pressure is light and the motion rapid, an effort is made to condense and harden the surface so that it will receive and retain a high polish.

WIRING PLATES.

When plain teeth have been adapted to a plate, and it is designed to place over them an artificial gum of one of the vegetable bases, it is advisable to attach to the labial and buccal edge of the plate a continuous wire, to round the edge, increase the means of retention of the artificial gum, and to lend additional beauty of finish to the piece. After the teeth have been fitted and tried in the mouth, the palatal line of the base of the last molar of each side is marked by a scratch on the plate. Beginning at this point at one side, a wire is curved over the ridge and to follow the edge of the plate until it terminates at the base of the opposite terminal molar: the stays of these teeth are to abut with the ends of the wire. A piece of triangular wire No. 18 gauge of the proper length is procured. This is annealed, boiled in the acid solution, and one face of it scraped to exhibit a fresh surface. The middle of the wire is usually attached first. A clamp holds that point of the wire against the plate at the depression for the frænum, the edge of the wire level with the edge of the plate, which is then set on a block of charcoal, the alveolar ridge portion resting upon the surface of the latter. The point of junction of the wire and plate is covered with borax and a small piece of solder placed over it. A fine blowpipe-flame is directed against the plate beneath the wire carefully avoiding contact of the flame with the loose ends of the wire, as these latter fuse very readily. When the solder flows, attaching the wire at this one point, the clamp is removed and the plate plunged in the sulphuric acid solution. The plate is placed upon the model or die and the wire bent, following the line of the plate. For about half an inch on both sides of the soldered point the wire is brought into close apposition with the plate, the edges of wire and plate in a line; the junction is boraxed, and held in place with a clamp or with binding wire, and joined to the plate by small pieces of solder. The remainder of the wire is, little by little, fitted and soldered until the extremities are attached and are soldered fast to the point at which the disto-palatal corner of the second molar touches the plate. As a final measure the entire length of the joint between the plate and wire is covered by borax, one or two small pieces of solder placed at points where the solder may be deficient in amount, and then the blowpipe flame is passed along the joint, filling the latter completely with the solder.

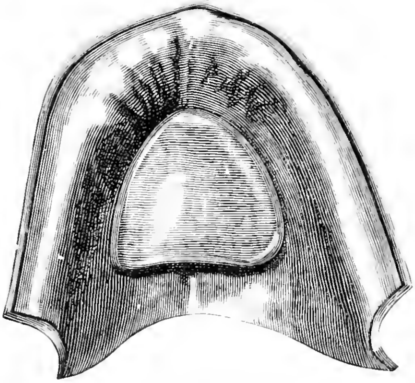
Should the case be one retained by clasps the wire is to be attached before the clasps are fastened to the plate. Before rimming or wiring it should be determined whether the plate edge is of the proper height or depth, for, should subsequent trimming of this portion of the plate be required, it is possible that a portion of the wire might have to be filed away, and thus mar the finish of the denture.

Cases which have the third molars remaining should have the wire

carried around the plate at the bases of these teeth (Fig. 555). This device may be used on upper, lower, full or partial dentures.

If the teeth have been fitted to the plate before the wiring is done they may be held together by plaster guides, and invested, much in the same way that gum teeth are in rimming. It is usually, however, better to wire the plate first, leaving the ends extending around the molars to be soldered when the backings are soldered.

Fig. 555



A metallic upper plate intended for a plain tooth denture, wired along its upper edge.

If the teeth are to be attached to the plate by means of vulcanite the wire is continued across the palatal aspect of the palate, following a line which marks the base of the wax. A pair of special, long clamps will be required to hold the wire in contact with the plate during the soldering operation.

PREPARING THE CASE FOR INVESTING.

All dentures of plain teeth, and partial dentures of gum teeth where they stand alone, or where not more than two or three are together, usually need no preparation for investing beyond seeing that the teeth are held so securely by the adhesive wax that there is no danger of their displacement when the denture is imbedded in the investment; but in cases where the gums are very long and are not supported by the plate, or have been ground very thin, it is a wise precaution to place a drop of yellow wax inside the weak gums, so as to prevent the plaster from coming into actual contact with them, and thus lessen the risk of their being broken when the case is removed from the investment after soldering.

In cases where there are a number of gum teeth together with the gums closely jointed, some provision must be made to prevent accident from their expansion when heated for soldering. If this is not done, there is serious risk of chipping at the edges where they are jointed together, or the teeth may be so broken as to require replacement. In

addition to this there is also a risk of the plate warping during soldering: where in lower dentures this occurs the plate usually curves inward, the distal ends being brought nearer together; in upper dentures the change in shape makes the plate press upon the hard palate, producing what is known as a "side rock."

To prevent these accidents take a strip of thin soft paper, such for instance, as the margin of a newspaper, and, beginning at the centrals, remove, one at a time, each alternate tooth, and place in the joint between the gums a thickness of paper, slightly wetting it so that it will lay flat, removing from the tooth with a grindstone a sufficient amount to allow for it. During soldering this paper is burned out before the heat has expanded the porcelain to any great degree, leaving between the teeth a slight space; if carefully done, however, the space made is so slight as to be unnoticed in the finished denture, while it effectually prevents the accidents referred to. To remove a tooth without displacing the adjoining teeth, pass a hot wax spatula by the side of the pins to soften the wax around them, and then push it off. If this is done carefully the wax is left so that the tooth can be accurately replaced, an application of the wax spatula securing it in place again.

INVESTING.

An investment is a device designed to hold the teeth and plate in their relative positions during the soldering operation. It is made of a material having a low degree of heat conductivity and sufficient coherence to ensure that it shall maintain its form when raised to a very high heat. By its relatively low conductivity it prevents too rapid heating of the porcelain teeth it encloses, and also the too rapid cooling when the source of heat is removed; either of which is a prominent factor in casing fractures of porcelain. The same physical property lends to the investing material the feature of maintaining the teeth at a constant temperature during the soldering operation. Plaster of Paris is the basis of the investment; to it are added beach sand or asbestos, so as to overcome its tendency to contract and to fracture when heated to a soldering temperature. About five parts of sand, or of a mixture of sand and asbestos, to four of plaster, makes a satisfactory investment.

Water is first placed in a plaster bowl, and to it is added a sufficient quantity of short-fibre asbestos, or woolly asbestos, or beach sand and asbestos, until the materials are just covered by a film of water, and the mixture is well stirred to distribute the asbestos or sand evenly. Plaster of Paris is next sifted in and stirred until a soft, plastic mass is made. About a spoonful of this is placed upon a glass slab, making a layer about half an inch thick. The denture is wet so that the investing material will flow freely into the spaces between the teeth. A portion of the material is taken upon the point of a spatula and worked into the deepest portions of the palatal surface of the plate: little by little more investment is quickly added until the plate is full, when the material is

then packed between the teeth, filling the spaces perfectly. It is then inverted upon the bed of the material upon the slab, and the investment built up about the teeth until they are covered by a layer half an inch thick. The lingual surface of the plate is covered to within about half an inch of the bases of the teeth. To ensure against fracture of the investment, a piece of round-wire, or several strands of binding-wire formed into a ring is imbeded in the investment. This is so bent that its arch shall be about a quarter of an inch larger than that of the teeth. When binding wire is used (Fig. 556), several strands formed into a circle are placed over the teeth, the front portion a little below the cutting edges of the teeth, and the back portion is bent downward to about the level of the plate. In either case this reinforcement is set in position when the investment is half complete and thoroughly imbedded in it.

Fig. 556

Several strands of iron binding-wire formed into a ring to reinforce the investment of an upper denture, showing the relative position of the wire and the plate.

The investing material is harder, but more friable and quicker setting than plaster alone; these manipulations must be quickly done. (Fig. 557.)

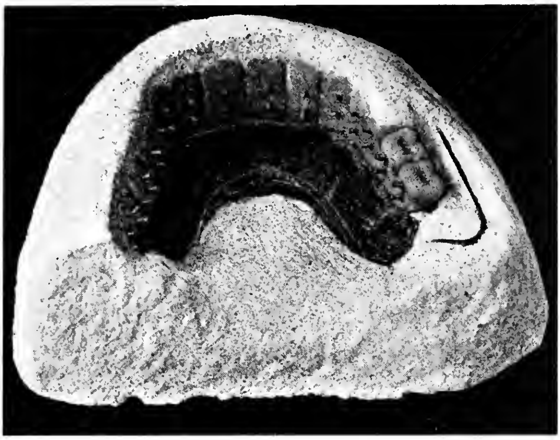
When investing delicate partial cases it is better to have the material rather thin, placing a mass of it upon the slab and then carefully laying the case upon it, work it down with a gentle rocking motion until there is rather less than half an inch under the deepest part of the plate: after this has become somewhat set, add more of the investment, building it up to and around the teeth.

The investment of lower dentures differs so little from that of upper dentures as not to require a separate description. (Fig. 558.)

When investing a denture, three points are to be borne in mind: First, be sure that the material is in contact with the under surface of the plate at all points, especially that it fills the bands or clasps of partial cases. If any vacancies exist there is danger of the plate being overheated and burned at that point, or of sinking in and thus im-

pairing the fit Second see that the teeth are well covered, not only to hold them in place securely, but also to protect them from direct contact with the blowpipe-flame. Third, see that the edges of the plate are

Fig. 557



An upper denture invested, and prepared for making the backings and for soldering. A portion is broken away to show the terminal of the reinforcing wire imbedded in the investment.

well covered: if this is neglected they are apt to curve up. It is desirable, however, that the surface of the plate be well exposed; for soldering, otherwise there may be difficulty in getting it hot enough (Figs. 557 and 558.)

Fig. 558

A lower denture invested, and prepared for soldering. A portion is broken away to show the terminal of the reinforcing wire imbedded in the investment.

Preparing the Invested Denture for Making the Backings, and for Soldering.—First, trim off such portions of the investment as encroach too far over the plate and the edges of the teeth; being careful, however, that while removing enough to give free access to the teeth for making the

backings, and exposing all portions over which solder is to be flowed so that they can be readily reached by the blowpipe-flame, that enough is left to hold the teeth securely and to protect all parts liable to be injured by unnecessary contact with it. Then, remove all redundant portions and trim to a neat easily handled shape.

Next, remove the adhesive wax, which to this point has held the teeth in place. This should be done mechanically; the use of heat, wet or dry, is inadmissible. A fine pointed instrument, or the narrow blade of a pen-knife, is an effective tool for this purpose. Care is needed in this operation to avoid fracturing the teeth by getting the instrument between their pins, or displacing the teeth. By picking and scraping every particle of wax under, between, and around the teeth must be removed, and the plate surface over which solder is to flow made clean and bright, especially if the plate is of silver. The pins should next receive attention, and be made clean and free from porcelain or other foreign matter adhering to them. Partial dentures require during this operation very gentle handling. Teeth standing alone are easily displaced, and the gums of gum teeth are readily broken.

If the backings have been previously made, the denture is now ready for soldering; if this has not been done, it may now be proceeded with.

MAKING THE BACKINGS.

As a general rule for all full dentures, and for all but the smaller partial dentures, it is more satisfactory to fit the backings after the teeth are invested. When the denture has been finally tried in the mouth with the teeth cemented in place, it is a serious risk to remove them again from the plate; notwithstanding the careful use of guides, slight changes of position are inevitable, and the artistic and mechanical adjustment thereby endangered.

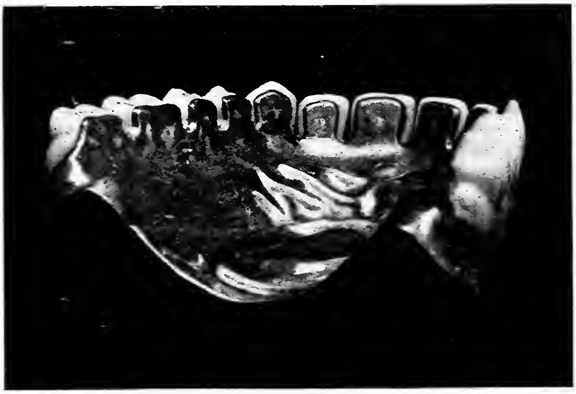
Before beginning to make the backings for a full denture, have the following tools close at hand upon the workbench: the plate shears; punch for rivet holes (select for this purpose a punch with short jaws; many are made with the jaws so long as to require a strong force to perforate the thick metal used in making backings); a strong pair of flat pliers (not too large), with beaks that will hold firmly; a five inch half-round file; a point that can be used as a reamer; a tool for countersinking the rivet holes—a large, obtuse-pointed spear drill, or a triangular scraper answers for this purpose; a small hammer; the bench anvil; a pair of broad tweezers or solder tongs; and a chisel for splitting the pins.

The thickness of metal to be used for backings will depend upon the length, position, and character of the teeth. Plain teeth, and all teeth that stand alone require stronger backings than do gum teeth, where the backings may be united a portion of their length. Long teeth and very narrow teeth require stronger backings than do short or wide teeth. Gold backings should be about No. 22 gauge, silver about two numbers heavier. The addition of a little platinum to the gold used for backings gives them greater strength and stiffness.

The backings should be made nearly as wide as the teeth. The length is sometimes a matter of taste; at other times it will depend upon the requirements of the case. If the anterior teeth are likely to be subjected to much strain in mastication, their backings should extend quite to the cutting edges, so that the opposing teeth will strike against them rather than against the teeth. In other cases they should terminate about half way between the upper pin and the cutting edge; this leaves the cutting edge more translucent. The backings should be uniform in height and shape, have the corners rounded and their surfaces neatly curved to a convex form. (Fig. 559.)

When backings are to be made for a full denture, it is time-saving to cut several strips of metal, about two or three inches long, and of suitable width, bevelling for their entire length both edges upon that side

Fig 559



Upper denture ready for the mouth.

which is to be the face of the backing: the strip is more quickly beveled than would be the separate backings. An upper denture requires the same width for the centrals and molars, another width for the laterals and bicuspids and canines, so that if each strip is cut slightly wider at one end than at the other, two strips will make all the backings. A lower denture usually requires three strips differing in width; one for the six anterior teeth, one for the bicuspids and one for the molars.

The author prefers to begin with the centrals in making and finishing the backings, making them in pairs, as by so doing they can be made more uniform. Having prepared the strips, place one before the tooth to be fitted, and, holding it in the position the backing will occupy, proceed to make the end resting on the plate fit the plate accurately by cutting with the shears or by filing. When this is done, mark the position of the pin-holes by placing it in position and while pressing it firmly against the pins impart to it a slight movement so that it will rub against at least one pin. This will accurately mark where the pinhole is to be punched. Punch a hole at the pin-mark most plainly to be seen, and after countersinking this hole proceed in like manner to mark the posi-

tion of the remaining pin. This method of determinig the position of the pin-holes has been satisfactory to the author for more than two score of years; it is cleanly, requires no additional tools or appliances, is quickly done and is accurate. If the holes when punched are too far apart, or to close, so that force is required to press the backing in place, there is danger of the tooth being broken in soldering. To remedy the first defect slightly enlarge one or both holes by punching a little from the inner side: the second defect is corrected by laying the strip upon the anvil and striking a few light blows with the blade of the hammer between the holes; this will spread then farther apart. Countersink the holes slightly on the side next the tooth, but quite freely on the other side, and remove the burr raised by the countersink. Then lay the strip flat on the bench, with the side that goes next the tooth uppermost, and strike a sharp blow with the blade of the hammer about the centre of its width, and near that end of the strip which has been fitted to the plate. The object of this is to curve it slightly so that its edges will fit more closely to the back of the tooth. Then place it upon the tooth and see that it fits solidly, and closely at the edges, and mark where it is to be cut off, making the front side a little higher so that it will be parallel with the cutting edge of the tooth. Cut it off and lay it aside, and proceed in like manner until all the backings for the denture in hand have been fitted, cut off, and arranged in order. The backings for the centrals are now filed into proper shape, and made as nearly alike as possible, then the laterals, and so on until all are completed. If the denture is of plain teeth, the backings may now be fixed in position by splitting the pins crosswise, and the preparation for soldering proceeded with. If of gum teeth, connecting pieces between the backings must first be fitted, unless this has been provided for when finishing the backings.

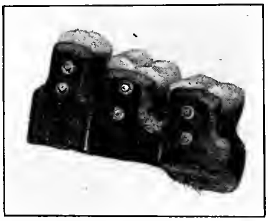
In all cases of plain teeth the backings must follow the outline of the tooth, being made quite as wide but no wider, otherwise they will be seen through the interspaces. In cases of gum teeth, if the strips from which the backings are made have been first beveled, as suggested, the backings are filed into shape precisely as though they were for plain teeth, no attention being paid to the offset marking the gum portion of the teeth until after the backings have been finished; then, preparatory to soldering them to the plate, in-between-pieces are fitted to make the backings continuous as high as these offsets extend in the following manner: narrow pieces of thin platinum plate (the thicker platinum foil prepared for inlay work is satisfactory), are cut extending from the top of the gum-joint between the teeth to the plate, and wide enough to be firmly held by the sides of the backings. Before the backings are fastened to the teeth these pieces are pressed across the joints, fitting any irregularities of form which may be present, the backings are placed in position in pairs, so that by splitting and bending down the pins the sides of the backings hold the platinum pieces firmly in position. When all the backings have been adjusted and fastened, small pieces of metal the same as that of which the backings are made, are beveled to fit the sides of adjoining backings, and long enough to hide the platinum: be-

fore placing them for soldering the surface of platinum is covered by borax, the small sections covered also with borax, and placed in position.

An alternative method is to make the backings wide enough to overlap slightly, and when filing them into shape to form a shoulder on each side slightly lower than the top of the gum-joint; one side of this portion is beveled outward and the other inward, and the backings neatly fitted, the one to the other, so that this portion of the backings forms a continuous level surface (Fig. 560.) That for the last molar is bent to meet the rim. If this is well done, it facilitates the soldering very much; there is nothing to be displaced, less solder is needed, and this smooth even surface is far more quickly finished.

In most partial dentures it is time saving, and more satisfactory to make the backings and solder and finish them before investing, especially in cases where teeth stand alone. The extra time lost by the two solderings is recovered by the time saved in finishing, and the work is usually done more neatly. If the case calls for exactness in the position of the teeth, the denture, after having been tried in the mouth is placed on the

FIG 560



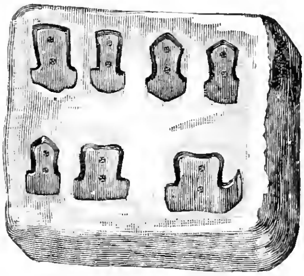
Backings shaped to cover the gum-joint and forming from the top of the gum-joint to the plate a continuous level surface. The backing of the last molar extends around that tooth to meet the rim.

model, and plaster guides made to facilitate their replacement, when these are hard, remove the wax, and proceed to make the backing precisely as though the denture was invested. The tooth may now be removed from the model and the backing fitted to the tooth, filed into shape, and secured to the tooth by splitting the pins with a sharp chisel or graver first crosswise and then lengthwise of the tooth, pressing the split portions apart so as to form a head to the pin filling the countersink. The tooth is now invested in a small mass of investing material (Fig. 561), care being taken that no portion is exposed other than that over which the solder is to flow, and equal care that no investing material is allowed to reach the pins; if it once gets there it is exceedingly difficult to remove. If the tooth is very small, and this is liable to happen, the pins had better be covered by a little mass of beeswax softened and pressed into position; so placed it will thoroughly protect the pins and is readily removed. It is advisable when soldering the backings to the teeth before they are invested to use a less fusible solder, one that will not be reflowed when the teeth are soldered to the plate. This can be quickly made by adding about one-fourth its weight of plate to the solder, thoroughly fusing the two under the blowpipe into a globule and forging it to

the right thickness. This holds good with silver solder, and with gold solder of any carat. Where a number of teeth are to be thus backed and soldered, the author has not found it advisable to place more than two in the same mass of investment; if a number are invested together they all must remain under heat until the last is soldered, and not unfrequently those first soldered are put to more risk after they are soldered than during the operation, because attention is especially directed to the one under the blowpipe and an accidental deflection of the flame impinging on the others may escape notice. After the backings have been soldered and cleansed in acid they should be filed to shape and polished with a felt wheel before being invested, as this can be more readily done now than after they are soldered to the plate.

If the surface of the tooth to be fitted with a backing is especially irregular, or a very close fitting backing is required, the above method may be modified by making a backing of thin and soft plate, securing it to the tooth by splitting the pins, and then wrapping it in soft paper, place it in a small "shot-swage" upon a bed of corn meal, fill the swage with corn meal and press it firmly between the jaws of a bench vise.

Fig. 561



Teeth invested to solder the backings.

This thin backing is thus brought into absolute contact with the porcelain of the tooth. The pins will usually be found projecting; they are again pressed apart and in contact with the backing, and a second backing of thicker metal, slightly smaller, and without pin-holes, is prepared to fit over the first and laid aside after being coated on the inner side with borax. The tooth with the first backing in place is now invested, provision being made for placing the second backing in position. The backing is now soldered, the solder being allowed to flow over it, the second backing placed in position and heat again applied to re-fuse the solder so as to unite the two thoroughly.

In many partial cases the backings may be fitted, soldered, and finished, before the teeth are fully fitted into position. In these cases the backings are made to extend to the base of the tooth, and are fitted to the plate by the grindstone at the same time as the teeth are fitted. Now and again it is desirable to do this, especially when the bite is very close; the tooth being tried in the mouth with the backings in place, ensures that it will not be in the way after the denture is com-

pleted. This, however, makes the trying in more difficult, as the teeth are held less securely to the plate.

PREPARING FOR SOLDERING.

When preparing a plain tooth denture for soldering, first fit between the backings little triangles of metal so as to connect them together at the plate line. These may be clipped from a piece of plate with the shears; the point which passes between the teeth should entirely fill the space, and may require bevelling on its under side so as to fit close to the plate, and not show through the interspace; the base of the triangle should be even with the backings. These pieces add very much to the strength of the denture, facilitate soldering, and permit a neater finish. A similar piece should be fitted to the back part of the last molar of each side. Plaster or whiting, mixed with water, is now packed between the teeth, over the tops of the backings, and in every space where there is danger of borax reaching the porcelain, or where the investment does not thoroughly protect the teeth. All parts over which the solder is to flow require to be coated with borax, ground with water to a creamy consistency; solder is now added, very small pieces over each pin, and a line of pieces about three-sixteenths of an inch long and one-sixteenth wide, are laid at the junction of the backings with the plate. This done, the denture is ready for heating preparatory to soldering.

Much the same procedure is required in the case of gum teeth, a little more care is needed in placing the protective investment between the teeth if the connecting pieces are separate from the backings, as it is depended upon to hold them in place. The arrangement of solder must also provide for uniting the backings. The last molar of each side must be connected with the rim, either by bending the free portion of the rim, left unsoldered for that purpose, close to the gum portion of the tooth, or by an additional piece if this proves too short. If there is no rim, a triangular piece of plate should be fitted to this part for the sake of a neater finish.

Partial dentures require in addition to this, reinforcing pieces over narrow portions of the plate supporting scattered teeth. These should connect with the backings and extend sufficiently far over the plate to impart the required strength and rigidity. The general reinforcing of the plate is best done when the plate is made; those points especially liable to change of form or fracture, are reinforced when the teeth are soldered. At this time the union of the clasps and plate is made more secure either by additional solder or adding pieces of plate; care being taken, however, to protect that portion of the joint which it is desired to remain unsoldered by filling it with plaster or whiting. Wherever around the necks of the natural teeth the plate is subject to strain it should be reinforced. In reinforcing, dependence should be placed upon plate, rather than upon solder; the pieces of plate used should be neatly fitted, the edges having first been bevelled. The borax, with

which the under surface should be coated can usually be depended upon to hold them in place during soldering.

SOLDERING.

General Considerations.—The following rules are to be observed in soldering:

When two pieces of metal are to be united by solder their surface should be as nearly as possible in perfect contact.

The solder used for dental appliances should be employed merely as a uniting agent, and beyond the amount necessary to perform this office it should form no part of a fixture. Any additional strength of the piece should be derived from additions of plate, not of solder.

Absolute chemical cleanliness of the surfaces to be united is necessary.

The thickest part of an investment is to receive the greatest volume of heat.

Solder flows toward the parts of highest temperature, so that in soldering, the part into or over which solder is to be flowed is made hotter than its surroundings.

With decrease in the thickness of the solder pieces, there is an increased surface of oxidation.

Solder should be placed at short intervals on the part of the fixture most difficult to heat.

Drying of the investment should precede the heating of it.

No tooth should receive the direct flame of the blowpipe until it is heated to redness by heat transmitted through the investment from the exterior.

Borax must not be placed on porcelain: it forms a contractible glass surface which in contracting produces enamel fracture.

In any piece where there may be several soldering operations, begin with a higher carat, or a less fusible solder, but in no case, and under no circumstances, use on new work a solder of a lower carat than the plate. The fusing point of any grade of solder may be raised by adding to it a portion of the same metal. Eighteen carat gold plate can usually be soldered with twenty-two or twenty carat solder, under favorable circumstances, if care is used. A workman, to whom a case is given for repairs, has a right to assume that it is of the same carat throughout, the attempt to use an appropriate solder would prove disasterous if in its original construction a low carat solder had been used.

SOLDERING AND FINISHING.

The denture, with the solder in place, is slowly heated over a gas flame, or in a charcoal furnace until the whole mass of the investment is at a red heat. There are two forms of blowpipe in use. In the older form the blowpipe is practically stationary, and the work is brought to, and manipulated under it. The newer form can readily be directed in

any direction. When this latter form is used the denture may remain upon the heating arrangement during the soldering operation. The details of soldering a denture can be learned only by observation and practice. Whether the denture remains fixed, or is transferred to some form of movable support, while the blowpipe is manipulated, the proceedure is much the same.

The broad blowpipe flame is thrown beneath the investment and passed rapidly over its outer wall, until the teeth and backings are made red by the transmitted heat and the solder begins to settle. The fine flame is now thrown upon the line of junction between the backings and plate, and carried from the terminal molar of one side to that of the other, the solder melting and flowing freely. Usually the solder above the pins and lateral joints is fused by the same flame; if not, if it does not flow freely about the pins and between the joints, a very pointed flame is directed at each pin and joint. More solder is added as it is needed; when it is obstinate it may be "coaxed" to the desired point by a pointed wooden-handled steel rod, long enough for comfortable use. This rod should be kept sharply pointed and clean. To flow as it should the solder exhibits a quick fluidity and has a smooth, even surface at the completion of the operation. The case is now permitted to cool slowly. When the backings are cooled, this is the test for the proper time of removing the investment; the latter is carefully broken away piecemeal. To avoid breaking long or thin gums the investment should be softened by being placed in warm water. The teeth and gums are now examined for any possible cracks or checks, as they are more readily seen while the case is dry. The piece is boiled in the acid solution, washed, scrubbed with soap powder, and dried, and then placed on the model.

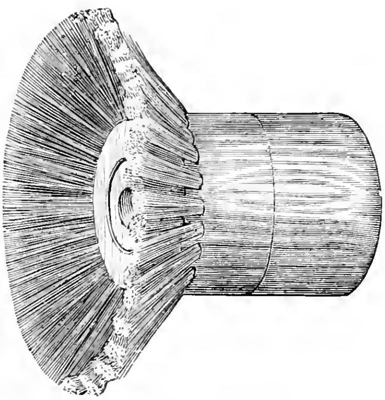
If the preceding operations have all been done correctly, the plate will have suffered no change of form and the porcelain will be intact. If, however, there has been any neglect of the minutiæ, all of vital importance, the plate may be warped, the porcelain gums checked, or one or more teeth cracked or in malposition. If the pieces have been accurately fitted and no excess of solder used, the succeeding operations are a comparatively light task, but none the less important. A small fine corundum wheel on the lathe is used to grind down the heads of the pins and to make uniform the joint at the bases of the backing. A wheel should never be used when and where it touches any point save the one upon which we desire to operate. Flat and half-round gravers are employed for the finishing, dressing, and scraping. The tops of the joints between the backings are given a uniform concavity by means of engine burs of the plug-finishing variety. The backings themselves and the plate are not to be reduced in thickness at any point, for this reason tools and appliances should never be larger than necessary to remove the superfluous solder.

Useful points for the smoothing of the surfaces of the backings and their joints are made of old corundum wheels softened by heat and drawn out into flat pencils. By altering the shapes of their points these pen-

cils may be formed so that they may be operated in any irregular places. After all of the surfaces have been dressed smooth, water-of-Ayr stones are used with water and finely powdered pumice stone, to give the final dressing; they are passed over every portion of the plate surface, obliterating all of the tool-marks and removing the outer coating of the entire plate. "To prevent the entrance of foreign particles in the spaces between the teeth and plate, and between the teeth themselves, the denture may be warmed, and melted paraffin flowed into all interstices: this is permitted to remain, as it effectually prevents the collection of débris and secretions in parts inaccessible to ordinary cleansing agents" (Bonwill). The piece is now transferred to the polishing lathe, where the smoothing is completed by means of fine felt-wheels and powdered pumice.

All scratches or tool-marks left upon backings or plate by the corundum wheel or graver in levelling the solder and platinum pins should be removed, first by the Scotch stone,[1] and then by a felt buff-wheel armed with fine pumice and water. Felt-wheels or cones of different sizes, some small enough to enable the operator to reach places difficult of access, should be kept ready for use. The case is held with the fingers embracing the outside of the teeth and supporting the body of the plate firmly, so that no uneven pressure is brought to bear upon the latter. Plates are occasionally bent during the finishing operation if held improperly. The piece is kept constantly in motion, so that while buffing there shall be no prolonged contact of the wheel at any point. The wheels as they are worn down are preserved for buffing small spaces When the surfaces of the plate and backings are perfectly smooth, the edges of the plate rounded and freed of all minute irregularities, a brush having a row of stiff bristles is substituted for the wheel (Fig. 562); this is passed rapidly over the surfaces of plate and backings, cleansing well the palatal surface of the former, but removing none of its fine lines. When all the surfaces have received a fair polish by this means, a similar brush is placed on the mandrel, and they are further surfaced, using a paste of chalk as the polishing medium. Succeeding this, a broad brush having fine bristles is employed with the chalk paste, to give a high polish to all of the surfaces—a sufficient finish to render the color of the solder undistinguishable. The plate is from time to time washed to observe the progress of these operations, and, after the buffing with

Fig. 562



Brush wheel, cup-shaped for surfacing.

[1] Otherwise known as "water-of-Ayr" stone.

chalk and soft wheel, is scrubbed well with soap to free it from all particles of pumice or chalk.

The case is now ready for the final polishing. For this, a brush wheel four inches in diameter, having the softest of bristles, is employed. A thin mixture is made of alcohol and the finest jeweler's rouge (an oxide of iron); this is painted over the surfaces of the denture, and the brush, revolving as rapidly as possible, is passed and repassed over all parts until the metal portions of the denture have a polish equalling that of the inner case of a watch. Every trace of the polishing powder is removed with soap and water.

Any rouge remaining about the joints which is not removable by soap and water, may be destroyed by touching the joints with nitric acid, then re-applying the soap.

SPIRAL SPRINGS.

Prior to the advent of the vacuum-chamber plates, the retaining appliance employed with full dentures was that known as spiral springs. Improvements in laboratory technique, comprised in better means, methods, and materials for impression-taking, together with a more accurate adaptation of plates, have so limited the use of these springs as to place them in the class of obsolete appliances. It is extremley rare that recourse to this method of retention is ever necessary. Springs are employed only when the anatomical configuration of the parts would render the employment of other retainig devices inapplicable.

Examples of such cases are found when any of the following conditions exist: extreme flatness of the arch; extreme contraction of the area upon which the plate rests; an exaggerated softness and thickness of the soft tissues of the mouth; or for attachment to obturators or artificial vela in edentulous cleft-plate cases, and prosthetic devices made necessary by surgical operations.

REPAIRING SOLDERED DENTURES.

The common casualties to soldered dentures which demand repair are cracks of the plate, fracture of one or more teeth, the loss of a natural tooth, leaving a gap in the arch, or requiring a readjustment of clasps.

When an addition of plate to overlie spaces left by the loss of a natural tooth or teeth is required, a plaster impression is taken of the part with the denture in position in the mouth.

The plate is to be withdrawn in the impression. A wax-bite, which has also been taken with the plate in the mouth and before taking the impression, is mounted and an articulation made. If the break in the outline be small and of regular form, a die is not required to fit the additional pieces. The edges of the plate surrounding the break are to be bevelled from the palatal side. If the edges of the break be more than one-sixteenth of an inch from contact with the model, a series of saw-

cuts are made along it, extending into the plate half way to the line of contact with the cast. A thin piece of metal similar to that of the denture is made to conform to the surface of the model: its inner edge is to come within the plate line as far as the end of the bevel, its outer edge to be on a line with the plate line.

A joint made between the plate and the supplementary piece is stronger when the edges of the plate overlap the patch: the adaptation is more accurate, and to secure the necessary strength it is not required to leave an unsightly protuberance. The leaflets between the small saw-cuts are now bent down, covering the added piece. The tooth or teeth are fitted to their places, and backings made. The several pieces are cemented together, and the fixture is invested; to prevent the investment filling the joint and excluding of the solder, the joint is covered with thin paper or filled with wax. The cement is picked away, the surfaces well covered by a cream of borax, and in the space between the backings and the plate edge surrounding the break a piece of plate of No. 26 gauge is set, fitting the piece beneath it. Solder is placed around the joints and the case well heated. In the soldering the heat is to be thrown upon the plate beyond the line of the break, so that the solder may be drawn beneath the plate and fill the joint. The deflected heat usually flows the solder about the pins of the teeth and at the base of the backing.

Should the space to receive the addition be large or have an irregular form, it is advisable to swage the piece. The plate edges adjoining the open space are to be bevelled, and the line of the edges traced on the model by means of a pin point. The plate is removed from the model, the latter is varnished, and a small die made of the part to be covered by plate. A piece of plate of No. 26 gauge is swaged to fit, and its inner edge cut down until it is slightly broader than the pin scratch on the model. Saw-cuts are made in the plate edges surrounding the break, and the leaflets bent down, holding the swaged section. The teeth are mounted and the pieces united as described.

Occasionally it is necessary to make the repair in two operations. It may be impossible to unite perfectly the piece to the plate and the tooth to both in one soldering. Such cases are found in those having a portion of the joint between the supplementary piece and the plate extend far beyond the palatal edge of the artificial tooth; for instance, where it is required to add an extension to the end of a lower plate, the additional piece being virtually a small plate covering the ridge. In such cases the piece is first swaged, fitted, and soldered to the plate, and the tooth or teeth mounted in a second operation.

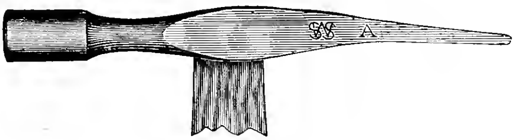
A common casualty, as noted above, is a crack in some portion of the plate. Such breaks are to be repaired by the addition of a strip of plate, never by solder alone. The case is cleansed thoroughly and the edges of the crack are brought together. Should the edges of the crack be separated more than about one-twentieth of an inch, it is inadvisable to attempt readjustment of the edges: the repair is to be made then with out any bending. The crack is filled with the cream borax. When this

is dry the plate is invested, the crack being just covered on the under side with thin paper—wetted so as to remain in place and prevent the investment entering, and a piece of plate of No. 28 gauge, about a quarter of an inch wide and extending the full length of the crack, is fitted to the plate over the crack. Its upper edges are bevelled, and it is well cleansed, and the surfaces to be united covered by the flux. A piece of solder is laid at each edge, and the case is heated and soldered: in finishing, the strip is to represent a rounded ridge. Should the crack be at the portion of a plate embracing the neck of a natural tooth, a semilunar piece is to be fitted over the plate and soldered to it.

When the teeth are broken from a denture an impression is taken with the plate in the mouth, an articulation made, the tooth fitted, backed, and soldered as with a new case.

If the tooth be broken away from its backing and lost, the repair may be made as follows: a tooth of the same mold and color is selected, the pin-holes drilled, not punched, as the latter operation invariably bends the backing. The tooth is ground into position: this operation will require some care, owing to the pins hampering the free mobility of the tooth in its space. If necessary, the pin-holes may be reamed

Fig. 563



Riveting hammer.

out and made larger. If there be any marked difference in the situations of the pins of the new tooth from those in the old one, the pin-holes are sawn into elliptical openings, and when the tooth is fitted the pins are so bent as to cover as much of the openings as possible. The case is then invested and soldered.

Should the other teeth of the denture be of such type as would be endangered by the heating necessary in soldering, or the repair be hurried, it is advisable to rivet the tooth to the backing. A tooth is selected having the pins at the same distance apart as in the old tooth. The pins of the old tooth are carefully drilled out of the backing, and holes are countersunk at the palatal side. The tooth is fitted to position, and a folded towel is laid upon an old counter-die, the tooth to be riveted set upon the towel, and no other tooth should press hard against the latter: repeated light blows of a small riveting hammer (Fig. 563) are directed against the ends of the pins until each is forged into the countersinks, filling them completely and leaving rounded heads, which are then burnished hard to complete the operation.

Cases will occasionally present in which an artificial tooth difficult to replace has broken away from its backing, leaving pins projecting from the back of the tooth about one-fiftieth of an inch long. Such a tooth is to be boiled in a test-tube with nitric acid. To its back is burnished

a covering of platinum plate, No. 36 or 38. Apertures are made over the stumps of the pins. The tooth and the platinum back are invested, a piece of pure gold is placed over each pin, and the platinum is soldered to the pins. The old pins are drilled out of the backing standing on the plate. The back of the backing is scraped to cleanse and thin it, and its top bent inward slightly. The tooth with the platinum back is set against the backing and cemented to it: the case is invested, and the platinum soldered to the backing, using a low-carat solder.

In repairing cases having a gum of one of the vegetable bases, if the backing be standing, the following method is frequently applicable: the rubber or celluloid is cut out to receive the neck of the tooth, but the festoon covering the latter is to remain untouched. A plain tooth is fitted to the backing, in which pin-holes have been drilled and countersunk. Phosphate of zinc colored pink with carmine is placed in the depression cut in the gum, and the tooth pressed into position: when the cement has set, the pins of the tooth are riveted as described.

To adjust broken or detached clasps properly it is necessary to take an impression of the clasp tooth with the plate in the mouth. Should the clasp itself be broken it is better to make a new one; the added plate and solder necessary to make it strong will, in most cases destroy its elasticity and impair its usefulness. Now and again a gold solder, lower fusing than the standard grade is required for repair work. Low grade gold solders should be sparingly used, as once used on a denture their use must be continued; the attempt to use solder of a higher grade afterward is attended with serious risk, owing to the reflowing of the inferior solder.

For this purpose the following formulas will suffice:

Sixteen carat Gold Solder.

16	parts	pure	gold,
5	"	"	silver,
2	"	"	copper,
1½	"	"	zinc,

Fourteen carat Gold Solder.

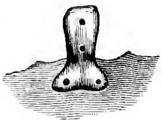
14	parts	pure	gold,
6	"	"	silver,
3	"	"	copper,
1½	"	"	zinc.

A lower grade than fourteen carat is inadmissible for dental work. These solders may be made more fusible by increasing the amount of zinc without reducing the fineness, and are so made for jewelers use. They are safe only in cases where the point to be soldered is alone highly heated, and where the work can be quickly done. This is not the case in the dental workroom. As soldering must be done by a dental mechanic, such solders quickly run through the plate, producing an injury difficult to repair.

A method of repairing metallic plates without subjecting the denture to the soldering operation, and, what may be more important, a means of attaching a clasp or an additional tooth to a plate without depriving the patient of the piece except for a few minutes, has been devised by Dr. Charles J. Essig.

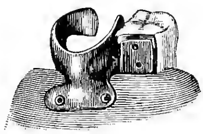
A typical application of the method will illustrate its advantages: A patient is wearing a partial gold plate; one of the remaining natural teeth is becoming progressively looser, and may be lost at any time; it is not permissible to deprive the patient of the piece for the length of tiem necessary to repair it by soldering. A bite and impression are taken with the artificial denture in position. If the operation be the preparation of an artificial tooth to be substituted for a loosening natural organ,

FIG. 564



Supplemental plate with tooth attached ready to be riveted to a denture. Used when it is desired to avoid the risk of soldering in repairing or adding to a denture.

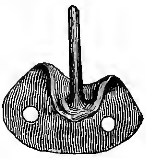
FIG. 565



Supplemental plate with clasp attached ready to be riveted in place. Used when it is desired to add a clasp to a denture and avoid the risk of soldering.

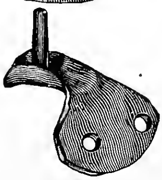
as soon as it is removed, the plaster tooth on the model is cut away, together with an amount of plaster to represent the condition of the soft parts after extraction. A die and counter-die are made, and a piece of plate No. 26 is swaged which shall overlap the plate as shown on the

FIG. 566



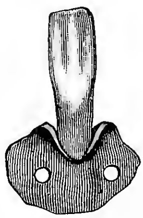
Front view of a supplemental plate with dowel ready to be riveted to a denture. Used when it is desired to add a natural tooth to a denture and avoid the risk of soldering

FIG. 567



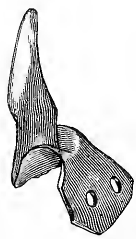
Side view of the same.

FIG. 568



Front view of the same with the natural tooth cemented onto the dowel.

FIG. 569



Side view of the same.

model, for one-fourth of an inch or more: a tongue to extend into the interdental space is to furnish a support to the artificial tooth. An articulating model is made, a tooth fitted to the model, and a backing adapted to it. The pieces are now invested and united by means of solder, then finished. The edges of the plate piece should receive a bevel, so that there shall be no abrupt line between the new and old plate.

To add a clasp, an impression is taken with the plate in position, and a model is made which shall have a perfect representation of the tooth to be clasped. The clasp is fitted to the tooth, and a piece of plate to the general plate, as described above. This is filed away about the base of the clasp tooth until it has a close joint with the clasp, to which it is cemented, invested, and soldered, and finished as described.

To add these pieces to the plate, three holes are drilled through the plate as marked in Fig. 564, and each is countersunk upon its upper side. When, in the first instance noted, the natural tooth is lost, or, in the second, the clasp addition is prepared, the piece is placed in the mouth with the plate itself in position, and by means of a sharp excavator point the outlines of the supplementary piece are scratched on the plate proper. With the pieces held in close apposition a drill is placed through the openings made in the small plate, and the plate proper perforated: the holes are countersunk at the palatal surface. Gold pins upon which rivet heads have been formed are placed through the openings and riveted, thus holding the sections firmly together.

It is at times preferable to add the natural tooth to the plate if it be one of the incisors or canines, and is free from caries. An impression is taken with the artificial denture in position, which need include only that part of the plate to which the attachment is to be made and the natural teeth immediately adjoining the loose organ. A supplemental plate of No. 26 guage is swaged, to which is soldered a stout platinum gold pin of about No. 16 of the standard gauge (Figs. 566 and 567). The plate is then riveted to the artificial dentures, the root of the natural tooth is cut off sufficiently to maintain the relative height, and the pulp canal is enlarged by means of a fissure drill so as to receive the gold pin. When the tooth has been carefully fitted, it may be permanently fastened to the plate (Figs. 568 and 569) by means of oxyphosphate cement.

CHAPTER XV.

CONTINUOUS-GUM DENTURES.

By D. O. M. Le Cron, M.D., D.D.S.

If it be agreed that beside the restoration of function, one of the chief desiderata in the construction of an artificial denture is the imitation of the natural appearance of the teeth and gums, then it may be said that the continuous-gum process offers greater æsthetic possibilities than those of any other method of prosthetic restoration. By its means the physical characteristics relating to the appearance of the restored tissues may be so closely imitated as to defy detection at the hands of the most skilled observers.

Continuous-gum takes its name from the fact that when the porcelain used for this purpose is fused upon a platinum base to which specially designed teeth have been attached, a porcelain surface is obtained which is without break in continuity between teeth and gums.

The first conception of the uniting of porcelain teeth to a metallic base by means of a fusible porcelain material originated in France. Among the names of those who first bent their efforts in this direction, may be mentioned M. Delabarre, of Paris, who in 1820 used a material closely resembling ordinary porcelain tooth-body to unite the teeth to the plate. Contemporaneous with that of this pioneer, we find the names of M. de Fouze, who applied jeweler's enamel for the purpose of restoring the contour of the gums, and of M. de Chemant, to whom patents were granted for the manufacture of a form of denture belonging to this type. The work of these early experimenters was attended in a large measure with failure because of the imperfect character of their materials and the lack of knowledge concerning the means for their proper fusing. Experiments with the silicious compounds were abandoned before any satisfactory results were obtained. This was because of the great heat necessary to work the materials used, for, according to Dr. Locke, they required a temperature of 3761° F. for proper fusing.

It remained for an American to realize the object sought by these early French investigators, and by practical researches to rescue from obscurity this beautiful process and place it before the dental profession upon a practial working basis. It was Dr. John Allen, of New York City, who in 1846 perfected a method of construction and compounded a porcelain body upon which he was granted patents in 1851. The priority of this invention was contested by Dr. William Hunter in a suit, accounts of which were published in the dental journals of that time. Dr. Allen surrendered his patents of 1851 because of defects in them, and in 1856, a new patent was issued to him for the process as he had then improved it. This was known as "Allen's Continuous-Gum."

Believing in the possibilities which this process offered, a few men have worked steadily since that time to improve and develop its details, and gradually many of the early sources of annoyance and failure, such as springing of the plate, and checking and sealing of the porcelain, have been overcome. The porcelain bodies now manufactured, are, if properly manipulated and fused, sufficiently strong to withstand any legitimate use. It is essential, however, that the porcelain should be superposed upon a metal frame-work constructed with strict regard to mechanical principles. Continuous-gum body of to-day is a silicious compound, similar in composition to that of which artificial teeth are made except that it is more fusible, its fusing point being 2300° F.

Platinum and iridio-platinum are used as the bases, and we find the tissues underlying them to maintain a condition more closely approximating the normal than under the vegetable bases.

The objections formerly urged against this variety of artificial denture, viz., its great weight and the dangers and difficulties in the baking of the porcelain, have been removed to a large extent by improved methods of construction.

The first objection as to weight may be overcome in a large measure by using the lighter gauges for the platinum base. The writer has for a number of years used Nos. 32 to 36 plate (B & S gauge) for upper dentures with most satisfactory results.

The use of modern electric furnaces effectually discounts any objections on the score of baking *per se*, for these appliances are thoroughly satisfactory in convenience of operation and efficiency. The consideration of the warping of the plate, the shrinking, flaking, under and over-fusing of the porcelain—accidents possible in the process of baking and urged by some as objections to the method, will be discussed at the appropriate place in this chapter.

As a minor objection may be mentioned the liability of fracture of the plate. Proper admonition to the patient as to the care of the denture should always be given, and by the exercise of due caution in cleansing the piece, any annoyance on this score may be avoided. Fracture in the mouth is of rare occurence.

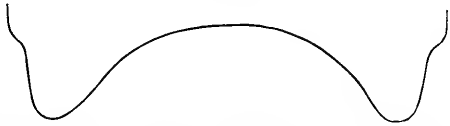
The tissues of the mouth react more kindly to the presence of a platinum base-plate than they do to any of the vegetable bases. All the materials of which the denture is composed being good conductors, the thermal variations are readily communicated to all the underlying parts. From a hygienic standpoint, the platino-porcelain plate stands alone. There are no interstices to catch food debris, and as the denture is absolutely uninfluenced by the secretions of the mouth, or the products of bacterial action, it may be made as clean and fresh as new by ordinary cleansing methods which may be instituted by the patient. One of the chief points of excellence in favor of the continuous-gum method is the facility and accuracy with which the natural organs are imitated. Any loss of gum or palatal contour may be so faithfully reproduced in form and color as to defy detection.

Continuous-gum dentures are applicable with most satisfactory results in full cases, upper and lower, but it is quite possible to employ them with good effect in many cases requiring partial dentures.

IMPRESSIONS AND CASTS.

The first requisite for success in constructing continuous-gum dentures is a good impression, and for this purpose plaster of Paris is the material *par excellence*. The manner of taking the impression and its subsequent treatment are described in detail in another section of this work. The cast is obtained and dies and counter-dies made as for

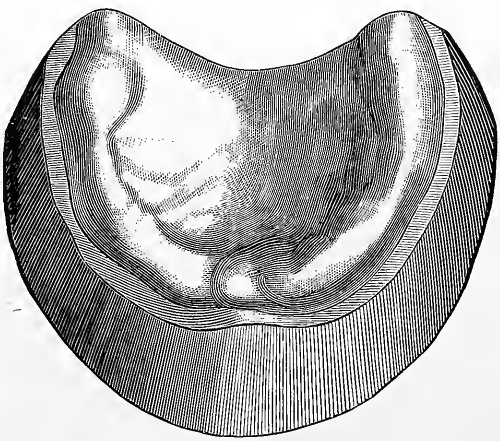
FIG. 570



Showing form of arch where chamber may not be necessary.

other varieties of metal dentures. The indications which govern the use of vacuum-chambers are the same as for other metal plates. If in the judgment of the operator a vacuum-chamber is indicated, it may be carved in the impression thus forming an integral part of the cast, or it may be placed upon the cast after the latter has been removed from the impression in any of the ways described in Chapter XI. In

FIG. 571



Cast of the upper jaw with ledge for turning the rim.

cases presenting well defined alveolar ridges and moderately deep vaults the vacuum-chamber is unnecessary. The firmness of the adhesion of the plate to the underlying tissues depends upon the accuracy of its adaptation to them. If this is perfect it will adhere with sufficient

tenacity, but if the plate is poorly adapted or warped in any degree, the stability of its retention is thereby lessened proportionately. If it is intended to swage a rim to the plate, especial care must be exercised in marking the outline of the latter on the cast. It should follow such a line as will prevent any possibility of its impingement upon the muscles of the lips and cheeks or other movable tissues. If after the piece is finished such impingement does exist, the beauty and finish of the plate would be seriously marred by trimming. A layer of wax slightly thicker than the proposed rim is adapted to the cast, following accurately the plate outline. It should form with the wall of the cast an angle, the degree of which should not be so acute as to interfere with accurate molding. The wax is then trimmed away to blend gradually with the sides of the cast. The cast thus prepared is now to have the necessary varnish applied and the die is obtained in the usual way.

Results obtained with dies made of nickel Babbitt metal, or Babbitt metal of Haskell's formula, will be found satisfactory in this work. The latter alloy contracts less than zinc, and plates made over dies composed of it fit the plaster cast as they do the die.

FORMING THE FULL UPPER PLATE.

The pattern of the plate in heavy tin foil is reproduced in pure platinum No. 32 to 36 gauge for upper plates, the thickness of the platinum depending upon the form and size of the plate. The writer has used all gauges and finds plate of these numbers, properly reinforced to meet the individual requirements, not only sufficiently rigid for all purposes, but contributing much to the lightness of the completed denture.

The face of the die is covered with a thin piece of wet muslin, and the platinum after being well annealed by placing the platinum in the electric furnace, bringing it to a white heat, and allowing it to cool slowly, is adapted as closely as possible to the palatal vault by pressure applied with the thumbs, and by the use of the horn mallet. Great care must be observed while annealing the platinum that no particles of zinc or lead are attached to it, for they would become alloyed with it, thus producing a hole in subsequent heatings, or causing the plate to crack or break in swaging, or possibly subsequently discoloring the porcelain paste. Using muslin over the face of the die, and pickling the piece each time before it is annealed to remove any possible trace of base metal will effectually prevent this. The process of swaging is continued, reannealing the platinum whenever its returning obduracy necessitates, until a fairly close approximation to the vault is obtained. A partial counter-die made of good modelling composition may now be used. The composition is softened and molded to the vault of the plate, completely filling the latter. It is then hardened by dipping into cold water. The composition is now placed in position on the plate which is in place on the die, and the whole is clamped securely to the bench with

an ordinary bench clamp, one arm of the clamp engaging the under surface of the bench, the upper arm engaging the composition. In this manner the plate is held securely in position on the die while its alveolar borders are adapted with the swaging mallet.

The soft platinum exhibits a tendency to wrinkle and tear under manipulation, so that all undue haste and force are to be avoided. If, however, the metal should be torn, small breaks in its continuity may be repaired by soldering a piece of thin platinum, gauge 36, over the hole with platinum solder.

When the adaptation to the die is as accurate as can be obtained by pressure and the mallet, the plate is trimmed approximately to the line marked on the cast. It is now ready for the counter-die, and extreme care should be observed to prevent contact of the platinum with the base metal of the counter-die, particularly if the latter be made of lead or an alloy containing that metal. As is well-known, lead and platinum combine with remarkable ease, and should small particles of lead become attached to the platinum when the latter is heated, the base metal forms an alloy with that part of the platinum with which it is in contact. This alloy is very fusible, and if the plate is not at once perforated, the part so contaminated will always be liable to this accident upon subsequent heatings. To avoid any such contingency it is well to interpose betweeen the surfaces of the counter-die and plate, wet muslin or thin rubber dam. This will also assist in disengaging the plate from the counter-die if, as frequently happens, it becomes wedged therein from the force of the swaging. Should the platinum become contaminated with the base metals, it must be pickled in hot nitric acid before further annealing.

The plate is at first lightly swaged between die and counter-die, then removed and examined carefully for wrinkling or breaks. Should wrinkles develop they should be corrected with pliers and the horn mallet. The swaging should alternate with pickling and annealing until the adaptation is perfect. The plate is then closely trimmed to the plate outline, leaving an excess sufficient for the rim if this is to be turned, and it is ready to be tried in the mouth. The rim is to be completely turned after the first coat of body has been baked.

The operator may prefer to solder a wire along the alveolar border of the plate instead of turning the rim, in which event the plate is to be trimmed to its true dimensions which are determined by trial in the mouth. The wire rim permits a trimming of the plate margins after the body has been applied and even after the plate has been worn. The vacuum-chamber in a continuous-gum denture is preferably formed in the plate itself, although it may be cut and soldered using for the chamber cap a piece of plate of the same thickness and soldering it in with 25 per cent. platinum solder. This is the solder employed to best advantage in continuous-gum work. The relative position of the pieces united by it will not change in the intense heat of the furnace. Pure gold may be used if the pieces are in absolute contact and a minimum amount of solder used, but an excess of gold should be avoided, as it is thoroughly melted and widely diffused by

the high temperature at which porcelain fuses. Solders containing base metals should never be used.

Strengthening Pieces.—The object of these is to add strength to the parts of the plate which are liable to undergo alteration in form, either when it is subjected to the great heat of the furnace, or under the stress of mastication. Those places in which experience has demonstrated the necessity of additional strength are the posterior border of the plate, usually referred to as the heel, and that portion of the plate extending posteriorly for a small distance from the alveolar border along the median line.

The form these strengthening pieces should take is governed by the judgment of the operator. The method of forming and adjusting them employed by the writer is as follows: patterns of heavy tin-foil are prepared; the pattern for the anterior piece is cut roughly to the form of a triangle, the base slightly overlapping the ridge anteriorly; the apex extending back toward the vault of the plate and lying on the median line, the size to be governed by the size of the plate. (Fig. 572.) This pattern is to be reproduced in iridio-platinum plate, No. 24 to 26 gauge, according to the case. The piece is well annealed, adapted to the die with the mallet and then swaged between the die and counter-die. It is now placed in position on the plate and both are swaged together.

Fig. 572

Reinforcing pieces for full upper denture.

The posterior pattern is cut in the form of a strip three-sixteenths of an inch wide, extending across the entire posterior border of the plate. This pattern is also reproduced in iridio-platinum No. 24 or 26 gauge. It should be observed that the object of this piece is two-fold; first, to give additional strength to the heel of the plate; second, to engage the porcelain and give finish to this part of the plate. In order to serve best this double purpose, the strip should be so formed that when finally adjusted its anterior edge is distinctly raised, while the posterior two-thirds of the body of the strip lie in close apposition to the plate. To accomplish this result a strip of brass is swaged to conform to the portion of plate immediately in front of and covered by the anterior border of the iridio-platinum piece when the latter is in position. The posterior border of the brass strip should be filed to a feather edge. The strengthening piece, having been adjusted to the die and swaged in the usual manner, is now placed in position on the plate with the brass strip properly interposed, and the pieces are swaged together

the baking of the body reduces the contraction, and maintains the contours in these regions. When the requirements of the case call for very short teeth, those employed in vulcanite or celluloid work may be used

Any artistic skill which the operator may possess has wide latitude for its display in the arrangement of the teeth. The varying facial expressions of the patient are studied closely and the endeavor is made to fix in the mind the natural expression both in repose and when the face is animated as in the acts of talking and laughing. Not only must an accurate knowledge of all the elements entering into and constituting what is known as the natural expression be borne in mind, but what is as equally important from a less æsthetic standpoint, a thorough knowledge of the mechanical principles involved in the retention of the denture. A just consideration of these observations leads to the further statement that in the construction of an artificial denture, the process is often attended by a series of compromises by which the

Fig. 574

Set of continuous-gum teeth.

various æsthetic features are reconciled to the practical requirements. Therefore, a comprehensive knowledge of all these factors will best place one in a position to so adjust the conflicting interests that the finished product will not suffer.

The central incisors are usually arranged first. Each tooth is ground to rest directly on the plate, and the pin should come in perfect contact with the wire on the top of the alveolar ridge presently to be described, or with the plate, in order to hold the tooth in position during the process of fusing the porcelain. Between each tooth and the platinum base there should always be two points of contact, viz: the platinum pin and the porcelain root; the teeth will then be less liable to change their position by the shrinkage of the porcelain. If the length of the roots is not sufficient to enable them to touch the plate, it will be necessary to support them in position by interposing little pieces of broken porcelain teeth.

Slight irregularities of alignment commonly found in the natural teeth

are easily reproduced and materially aid in giving a natural appearance to the case.

There are often conditions of the remaining natural teeth resulting from decay and organic discoloration, which make it impossible to find in the stock of the manufacturers a desirable match for a partial denture. Such needs of the operator can only be met by selecting a porcelain tooth, the body of which is the same general color as the natural teeth to be matched and treating it with mineral colors in imitation of the natural organs.

After the arrangement is completed in conformity with the ideas of the operator, the teeth are attached to the plate with adhesive wax.

Fig. 575

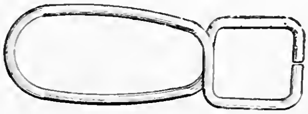
Base-plate with teeth arranged upon it.

Wax is also loosely molded over the buccal and labial walls of the plate to approximate the natural contours.

The piece is now transferred to the mouth, the articulation noted and any slight corrections or alterations made. The amount of wax necessary to restore the contours is also to be noted; this serves as a guide in the application of the body.

The next step is the adjustment of the iridio-platinum wire around the crest of the ridge, which serves for the attachment of the pins and also gives additional strength to the plate. The writer advocates the use of No. 16 iridio-platinum round wire instead of the platinum strips

Fig. 576



Clamp for holding reinforcing pieces on plate during soldering.

which are sometimes employed. The porcelain adapts itself more uniformly to the wire and fuses with less tendency to crack.

In determining the proper position for the wire, the plate is placed on the cast, and a wall of soft modelling composition is adapted to cover the anterior and lateral walls of the cast and all exposed portions of the teeth, and extending from the last molar on one side to the same tooth on the other. The composition is hardened and the wax removed thus freeing the pins which are bent slightly upward. The wire is adjusted

under the pins and waxed to the plate. The teeth should then be removed *en masse* with the composition. The wire is now held in position on the plate with clamps like that shown in Fig. 576 and soldered. The modelling composition wall containing the teeth is then returned to the plate in position on the cast, the pins bent down in contact with the wire, and securely attached with adhesive wax. The composition wall may then be softened by dry heat and removed, taking care that the wax about the pins is not melted and that the relation of the teeth to the plate is undisturbed. A plaster wall may be used instead of the one described. After the teeth are attached to the plate, the case is ready for the investment.

INVESTING.

The investment best adapted for continuous-gum work is composed of fine asbestos, one-sixth; coarse calcined silex, one-half; plaster of Paris, one-third.

The investment best adapted for continuous-gum work is composed ciently plastic to flow freely between and around the teeth. All surfaces of the teeth to be embraced in the investment should receive a coating of thick shellac varnish. This is to prevent the fusing of the investment with the porcelain teeth during the soldering, an accident which is likely to occur at the high temperature required to fuse platinum solder. The shellac burns out when the plate is heated up and leaves a small space about the teeth.

To make the investment small, uniform in thickness, and compact, a matrix into which it may be cast, is formed by placing the plate with teeth attached upon a flat surface like the work bench, the occlusal surface of the teeth being uppermost. Then a strip of base-plate wax is bent into the form of a ring, which shall surround the plate, follow its general form, and be one-quarter of an inch larger in each direction. The ring should be deep enough to extend one-quarter of an inch above the cutting edges of the teeth. The ring thus prepared is now set on a glass slab and attached thereto by passing a hot spatula around its edge. This forms a cup-like matrix into which the investment is cast.

The investment is now mixed as described above and first applied thoroughly to the palatal surface of the plate, allowing it to flow between and over all exposed portions of the teeth. The matrix is filled three-quarters full and the plate inserted, palatal surface downward, and pressed down until it is within one-sixteenth of an inch of the glass slab. The excess of material is forced up and around the teeth, covering the incisal and occlusal surfaces to a depth of one-sixteenth of an inch and filling in the lingual side of the vault.

The investment should be fully set before it is removed from the matrix. After it is thoroughly dry and hard, the wax may be detached from the teeth by subjecting the case to dry heat until the platinum becomes warm, when the wax may be readily removed. Hot water should

never be used as it destroys the integrity of the investient material, thereby frequently causing it to fracture under the subsequent application of heat.

All surfaces from which the wax has been removed are to be thoroughly cleansed with chloroform.

SOLDERING.

The pins of the teeth are bent so they are in perfect contact with the wire and plate. Small squares of platinum solder are placed at these points of contact and retained in position by a coating of borax. The borax is not intended as a flux, as the noble metals do not oxidize and a flux is not required, but it keeps the solder in place.

There are numerous methods of heating up the case preparatory to soldering. Quite a satisfactory one which the author has frequently used is to set the invested case in a bed of broken pieces of burnt fireclay over a Bunsen burner. This fire-clay is prepared by incorporating with it starch or sawdust, breaking it up into pieces of suitable size, and

Fig. 577

Full upper base-plate, showing wire soldered upon top of ridge and teeth soldered on.

firing them. The combustible constituents burn out, leaving the pieces porous. When thus prepared the mass may be heated thoroughly in a very short time, and it also possesses the advantage of cooling slowly.

With the aid of an ordinary gas blowpipe the case is gradually heated to a dull orange color (2000° F). The flame from the oxy-hydrogen blowpipe is then directed against the parts to be soldered until the solder flows.

Each pin should be carefully examined to see that it is securely attached to the wire or plate. When we are assured of this the case is allowed to cool gradually; this is conveniently done by placing a cover over the receptacle containing it. When quite cool the investment is removed and the denture boiled in dilute sulphuric acid, and washed in water until every trace of foreign substance is removed. It is now ready for its final trial in the mouth. The adhesion and articulation

are noted; any slight corrections in the arrangement of the teeth may be made at this time. After it is removed from the mouth the plate is placed on the cast, and all surfaces of the platinum to which the porcelain is to be applied are roughened by gentle scratching with a sharp excavator.

The plate is made scrupulously clean by washing with chloroform or alcohol and is ready for the first application of body. The utmost degree of cleanliness must be observed in all the subsequent manipulations. Any dust or particles of foreign matter coming in contact with the porcelain body will seriously affect the beauty and integrity of the finished product.

The Porcelain Body and its Manipulation.—The degree of success to be achieved now depends upon the skill and judgment manifested in dealing with the purely ceramic features of the case. The manipulation of the porcelain paste is considered in three stages; upon the application and carving of the first coat of body largely depends the final artistic effect. For the application of the paste and its æsthetic carving the set of instruments illustrated in Fig. 578 will be found very useful.

FIG. 578

Instruments for carving the porcelain paste.

The porcelain body *is* prepared on a clean glass slab. It is mixed into a paste with distilled water to the consistence of thick cream. It is applied first to the lingual concavity of the palatal portion of the plate, between and about the roots of the teeth, jarring the plate at intervals to insure compactness of the body. The moisture rising to the surface is to be absorbed with clean blotting paper cut into strips for the purpose. If slight pressure is exerted with the blotting paper upon the surface of the body, it will be condensed and less shrinkage will ensue. When this portion is covered uniformly to the proper thickness, which is that of No. 24 gauge, the rugæ and other features found in the roof of the mouth are modelled in the body.

On the labial and buccal surfaces the paste is applied in the same manner. The contours of these regions are roughly brought out in the manipulation of the body, but no attempt is made at accurate carving. No instructions may be given as to the correct carving of these features. This must be learned by a close observation of nature and by abundant practice. The crowns of the teeth are kept well defined and thoroughly freed of any adhering porcelain paste.

To prevent the teeth from moving and the plate from warping by the contraction of the body in fusing, it is necessary to take into account the shrinkage which will take place in this process. Shrinkage occurs

in three stages of the baking:–first, as the water dries out of the mass and the solid particles more closely approximate each other; second, when the particles begin to combine by fusing; third, as the mass becomes vitrified. The principal cause of shrinkage may be said to be the agglomeration of the particles which were previously mechanically separated by the water expelled in the drying out process. This is followed by the fusing of the component parts of the body, and further contraction is due to this.

When the mass of porcelain is attached to a platinum base, it will either separate at its weakest place or the plate will warp; consequently, to prevent either of the above contingencies, shrinkage must be provided for by dividing it into small masses so disposed that their contraction will neither disarrange the teeth nor warp the plate. A fine ribbon saw is passed between each tooth dividing the body entirely to the base. The cuts are continued on the lingual aspect of the plate.

It is noticed in firing the low fusing bodies, that the contraction is largely vertical, because of their tendency to assume a globular form when fused. The high fusing bodies stand as carved, contracting symmetrically to the mass when uninfluenced by any extraneous factors.

The case now ready for the first baking, is placed in the furnace resting upon the palatal portion of the original investment, or better, upon a support of iridio-platinum wire bent into a "V"-shape with upturned ends.

FURNACES.

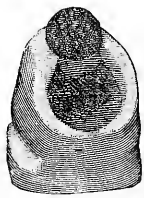
The great length of time necessary to heat up the old style porcelain furnaces was a strong objection to this kind of work; consequently, to meet the requirements of the present day a furnace intended for continuous-gum work must be available, which can be used with the expenditure of less time than formerly. It must be so constructed that there is no possibility of a contamination of the porcelain denture by the products of combustion.

Wherever it is possible to use it the operator will make no mistake in selecting one of the approved electric furnaces which the manufacturers are now offering. Among the many advantages possessed by this type of instrument, may be mentioned the facility with which it may be handled, and the small space which it occupies. With it there is no danger of "gasing" the work. Its cleanliness, the complete absence of odor and noise, and its beauty of finish as now constructed, recommend it highly in the furnishing of a well equipped laboratory. If lack of space in the laboratory prevents, it may even find a place in the operating room. The chief advantages, however, of the electric furnace are the ease and accuracy with which the requisite heat may be applied, controlled, and maintained. The construction of the furnace is such that the case may be heated uniformly and evenly throughout, the degree of heat is under perfect control, and it is claimed that porcelain fused by this method possesses unusual clearness and density.

In those localities where the electric current is not available, the operator may find his demands satisfactorily met by the use of some form of the gasoline furnace. Very excellent results may be obtained by this method of fusing porcelain and the country practitioner need not hesitate to undertake the work with a furnace of this character. The electric, gas and gasoline furnaces are described in the Chapter on the Laboratory.

A thorough acquaintance with the management of the furnace is indispensable, as probably the most prolific source of failure in continuous-gum work is lack of knowledge in this regard. Each individual furnace should be accurately tested by the operator and its working capabilities carefully observed. The temperatures at which the different porcelain bodies and enamels fuse should be noted; also the effects produced upon them by variations above and below their fusing points. Where a case necessitates several bakings with the same body the temperature scale must be marked for the proper limit of fusing for each baking. Because of the fact that the formulæ of porcelain bodies and enamels on the market vary in composition, fusibility and other physical properties, no general rule can be given for the regulation of temperatures. If the composition of all the bodies was the same and their working qualities were constant, the fact would still remain, that each furnace is a law unto itself. This applies not only to furnaces of different manufacturers but to those of the same make.

Fig. 579



Pyrometer designed by the author.

Until recently, no positive test for the correct fusing point was known. Fairly good results may be obtained by placing a pellet of pure gold in the muffle of the furnace near the plate, and after this melts at 2016° F., by maintaining the heat for a definite length of time.

More accurate results are secured by using the pyrometer (Fig. 579), designed by the author. This device is exceedingly simple in construction. A small cube of soap-stone is excavated to resemble an hour glass; into the upper expanded cavity is placed a small spherical mass of an alloy composed of platinum and gold. The relative proportion of the two metals governs the fusing point of the alloy; so by varying the proportions, the temperature may be graduated to any extent within the limits desired. The proper temperature of fusing for a given body is matched with a pellet of alloy. The pyrometer is set in the muffle, and when the temperature at which the porcelain fuses has been reached, the little metal ball melts and runs down into the lower chamber.

Below are tabulated the results of experiments conducted by the writer with the pyrometer to determine the fusing points of some of the more prominent porcelain bodies found on the market.

Allen's body	2340° F.
Close's body	2290°
White's inlay	2260°
Brewster's foundation	2220°
Consolidated continuous-gum	2200°

Consolidated inlay	2140° F
Whiteley's	2140°
Brewster's enamel	2090°
Ash high fusing	2010°
Jenkins prosthetic	1830°
Jenkins inlay	1580°
Gum enamel (Close and Whiteley's combined)	2140°

In the further prosecution of these experiments, the writer is led to the conclusion that the maximum strength obtainable in porcelain is developed by the proper regulation of the heat. If underbaked it will be brittle, flaked and incapable of withstanding the stress of mastication; while overbaking causes porosity and diminution in power to resist crushing stress.

First Baking.—The piece is placed in the muffle of the electric furnace. It is desired to heat it up slowly at first, so that it may dry out, and so that it will not flake by the sudden formation of steam in the body from the water used in mixing it. The heat is turned on and gradually raised, placing the lever of the rheostat on the first button. It is allowed to remain on the first button for five minutes and then turned to the next button; on this and each of the following buttons it remains two or three minutes, until the last one is reached, where it rests.

During this time the case is watched carefully to determine the proper degree of baking. Less heat is required for this than for subsequent firings. The baking is carried to what is known as the granular stage, at which point all shrinkage has taken place. The surface is not quite glazed, but presents rather a frosty appearance.

When the process of fusion has reached the desired stage as indicated by the pyrometer, the rheostat is thrown back and the current turned off and the case allowed to remain in the muffle until cooled. It is then placed upon the die and the rim turned with flat-nose pliers and riveting hammer, holding the plate firmly in place. The rim is turned to the desired angle, which depends upon the thickness of the gum, the purpose being to make the external surface of the rim and that of the porcelain of the gum continuous in the finished piece. The case then presents the appearance illustrated in Figs. 580 and 581.

The plate is now ready for the second application of porcelain. The paste is mixed and applied as in the first instance, filling in the fissures and restoring more fully the contours. When this is done, all traces of the paste are removed from the surfaces of the crowns of the teeth and platinum base which is not to be covered with porcelain. This may be done with a camel's hair brush, the bristles of which have been cut off close to make them stiff. The plate is now placed in the muffle as before and subjected to the second firing. The temperature for this operation is carried a few degrees higher than in the first baking in order to produce more complete fusion of the porcelain body. The porcelain body is brought just to the verge of a glaze: its surface should show a sparkling granulated appearance. Carrying the heat beyond the stage necessary to produce this effect lessens the strength of the

porcelain, and makes it impossible to obtain the translucent appearance of the gum when the gum enamel is applied. (Fig. 582.)

After being allowed to cool as before, the plate is tried in the mouth to note if any alterations in its form have taken place. The extent of the buccal and labial contours of the plate is also noted. If too full at any place they may be reduced by grinding; if lacking at others, more porcelain may be added, and the piece rebaked.

Fig. 580

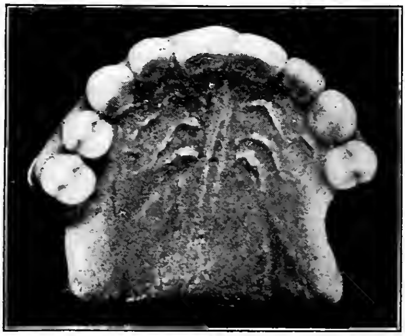
Labial and buccal view of denture after first baking.

Applying the Gum Enamel.—The gum enamel is now prepared by mixing it with distilled water and it is applied in the same manner as the body. The denture should be wet to facilitate the placing of the enamel. This layer should be thin and so applied as to preserve the distinctness of the gum outlines. By varying its thickness those differences in shade observed in the natural gum over the roots of the teeth may be secured

Fig. 581

Lingual view of full upper denture after first baking.

Fig. 582



Lingual view of partial upper denture after second baking.

as the yellowish white of the body is allowed to show through more or less clearly at these points. The outlines of the necks of the teeth, and rugæ are clearly defined. All superfluous portions of the paste are carefully removed, using small camel's hair brushes and instruments designed for the purpose. The piece is again subjected to the heat of the furnace.

The exact degree of heat necessary to develop the full beauty and strength of the case can only be determined by experience. When the heat approaches the fusing point, it is well to turn off the current and make an inspection. When finished, it should present a smooth, glossy appearance. If the heat is carried a few degrees too far, the color begins to fade and its brilliancy is lost. Frequently little pieces become detached and minute cracks present themselves. These defects may be remedied by applying more enamel, and repeating the baking. The natural gum effect cannot always be secured with the enamels as found on the market. A combination of several of them often produces the shades desired. The writer obtains desirable results in many cases by combining the Close and Whiteley gum enamels and adding a small quantity of White's inlay body. Doubtless other combinations produce equally good results. With the exercise of patience the operator can obtain almost any shade desired.

Fig. 583

Lingual view of upper denture after baking of gum enamel.

Fig. 584

Lingual view of upper denture after baking of gum enamel.

The finishing process consists simply in smoothing and polishing the metallic surfaces and washing the plate. The metal portions must have any marks due to files or pliers removed, and the polishing is done on the lathe in the same manner as for any other metal plate.

Mineral Paints.—As previously mentioned, there are often conditions of the natural organs associated with decay and discoloration from other causes, which may be imitated in the porcelain teeth by the judicious application of mineral paints. The method of applying and fusing these paints may be readily learned, and a little study in the mixing and blending of colors will enable the operator to produce very correct imitations of these defects in natural teeth. (See Chapter XII.)

These stains are applied on or around the cervical margins, the cutting edges, occlusal surfaces, or any other portion of the tooth, imitating those discolorations seen in the recession of the gums, mechanical abrasion, devitalized or decayed teeth. The effect is still more pleasing

if previous to staining, the cusps or edges of the teeth are ground off to imitate the wear incident to age. Pitting or other defects of structure which obtained in the natural teeth, may be well imitated by this procedure. There is practically no limit to the possibilities offered by this process in the hands of a skilled operator.

FULL LOWER DENTURE.

The general considerations set forth under the discussion of the full upper continuous-gum denture, apply equally to other forms of dentures embraced under this title. Hence in discussing the full lower or the partial upper and lower dentures, it will only be necessary to men-

Fig. 585

Buccal and labial view of denture after baking of gum enamel showing imitation of recession of gums, and staining of necks of the teeth.

tion those departures from the general line of procedure which are made necessary by the requirements of the particular case.

The first step in the construction of the full lower case is that of forming the pattern. Heavy tin foil is accurately adapted to the die and trimmed slightly larger than the plate outline to provide for any pos-

Fig. 586

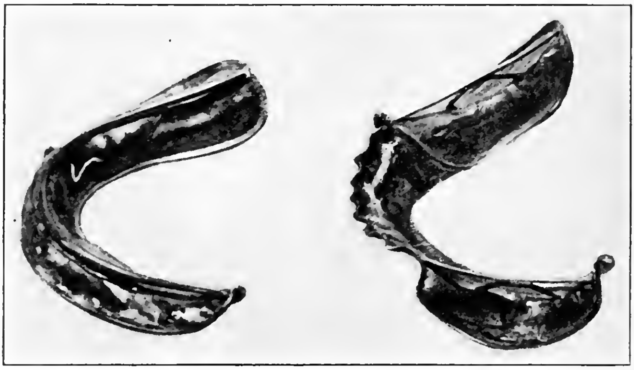
Buccal and labial view of denture after baking of gum enamel showing omission of one tooth and irregular alignment.

sible displacement of the plate in swaging. Great care must be observed in preparing patterns for lower and partial cases to prevent change of form when the tin foil is flattened out, for should this occur, a plate cut to such an inaccurate pattern would be useless. Because of the inherent weakness in the shape of a lower plate, heavier gauges are used than for upper cases, and furthermore, these are specially reinforced.

The quality of lightness is not so much a desideratum as in the upper plate, and strength may be gained in this manner without affecting the success of the denture. The pattern is reproduced in No. 28 to No. 30 gauge, platinum plate, and this is reinforced around the anterior lingual curve with a piece of iridio-platinum plate No. 26 gauge. The supplementary piece should extend from the rim on the lingual surface, up and well over the ridge as in Fig. 587.

The rim may be turned as for an upper plate if it is desired, but a platinum wire No. 18 gauge, soldered along the borders of the plate is to be preferred. This will not only provide additional strength, but it permits the trimming of the plate edges which is so often necessary

Fig. 587



Reinforcement of full and partial lower plates.

with lower dentures. An iridio-platinum wire No. 14 to 16 gauge, is to be adjusted on the ridge of the plate under the pins of the teeth, as in the upper plate. This serves for the attachment of the pins. The subsequent procedures are the same as those outlined for a full upper case.

PARTIAL DENTURES.

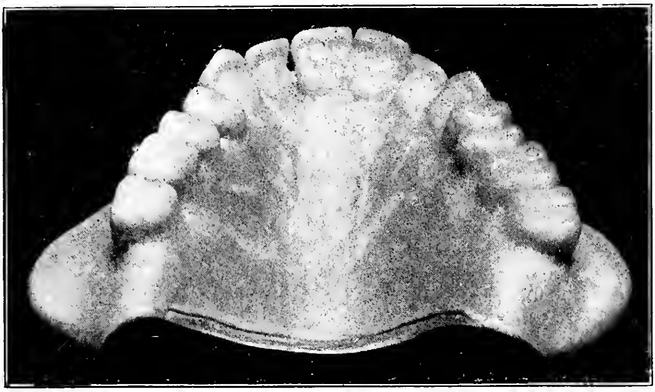
Continuous-gum is employed to best advantage for partial restorations in those cases in which the teeth to be replaced are in an unbroken column. More patience and skill are required in the construction of partial dentures than in either a full upper or lower. Each individual case presents features peculiar to itself, and each will suggest the proper procedure. The chief difficulties encountered are in preventing the plate from folding or splitting during the swaging. Frequent annealing, the skillful use of the pliers and mallet, and the cutting away of the surplus metal at difficult points about the natural teeth, will aid in avoiding these dangers.

Partial Upper Dentures.—When a partial upper case presents, the first thing to be determined is the mode of retention. There are two general methods by which the stability of the plate in the mouth may be secured. In the one case, the retention is obtained by the combined

forces of atmospheric pressure and adhesion, the plate covering the entire surface of the hard palate. In the other case the retention depends upon attachment to the natural teeth remaining in the arch, the plate being in the form of a horseshoe, and covering only the alveolar ridge.

To illustrate the application of the first method, we may take a form of denture carrying the posterior teeth. Obviously, retention by clasps in this case would be unsatisfactory, although it is possible even here to obtain fixation in or to the natural organs by special means. Two patterns are prepared: that for the primary plate extending over all surfaces intended to be covered; viz—the vault of the mouth, alveolar ridges and buccal surfaces. This is reproduced in No. 34, platinum plate. The second pattern is reproduced in No. 30, iridio-platinum plate. It conforms to the shape of the first except that it does not extend over the ridges.

Fig. 588



Full upper denture with lingual surface of teeth carved in porcelain; denture carrying large contours. (Wilson.)

Each lamina is swaged separately and then the two are swaged together. They are then united with platinum solder, the lateral margin of the supplementary piece being left free to form the lingual boundary of the porcelain. In this case the palatine surface is not covered with the body and no rim across the posterior border is required. The buccal rim may be formed by turning or wiring.

The patterns for the denture to be retained by the second method are adapted to the cast, and conform to the horseshoe shape, leaving the height of the vault free. The denture is preferably constructed of two laminæ, the primary of No. 30 gauge platinum, the second of No. 26 to No. 28 gauge, iridio-platinum plate. They may be cut to the same pattern, though the borders of the first should be allowed to project slightly to provide support for the solder. The rim and lingual boundary of the porcelain is formed by attaching No. 18 platinum wire. This style of denture may be used to replace the anterior teeth with some of the bicuspids or molars remaining to afford attachment for the clasps. These latter are adjusted as for other swaged plates, but iridio-platinum

must be used instead of the clasp metal, as the latter will not stand the high temperatures of porcelain baking.

Combination clasps of platinum and clasp metal may be made and attached in the following manner: the clasp metal is cut and adapted to conform properly to the tooth; around this is adapted thin iridio-

Fig. 589

Occlusal view of completed full lower dentures.

platinum. The iridio-platinum clasp is waxed to the plate, removed, invested and soldered. It also serves as a matrix against which to build the body. The ceramic part of the denture is then finished and the gold clasp placed in position in the attached clasp, properly invested and soldered with 18-carat gold solder. The objection to this

Fig. 590

Lingual view of completed upper denture.

combination lies in the fact that in case the denture requires repairing, the use of low fusing body is necessitated.

Partial Lower Dentures.—An ordinary form of partial restoration to which continuous-gum is applicable is that replacing the inferior bicuspids and molars. For these cases the pattern is reproduced in plati-

num plate, No. 30. A common source of annoyance in swaging plates for such a case is the tendency of the anterior part of the plate to displacement downward on the die. This may be prevented by allowing the sheet metal to extend over that part of the die representing the teeth and by bending it over their occlusal ends. A reinforcing piece of No. 24 iridio-platinum plate is applied to that portion of the lingual surface of the plate lying behind the natural teeth. This should extend well beyond the remaining teeth on each side and from the lower to the upper borders of the plate. The break in the continuity of the plate at the site of the natural organs makes it imperative that additional strength be provided to overcome the natural weakness at this point.

The rim is formed by soldering platinum wire No. 18 to the free margins of the plate. The other boundaries which limit the porcelain should likewise be covered with the wire. It will be observed in the illustration (Fig. 587) that the porcelain is not to be carried across the anterior lingual surface but is limited by the wire. If the curve of the alveolar ridge is marked the plate may be braced as illustrated in Fig. 587.

TUBE TEETH WITH CONTINUOUS-GUM.

M. B. Platschick of Paris, has a very ingenious method for the use of tube teeth in the construction of continuous-gum dentures, by means of which he obviates the necessity of primarily attaching the teeth to the plate with solder.

A platinum plate of full size is swaged after the ordinary methods; then another narrow plate is swaged to cover only the ridge or places where the pins are to be attached and the two are soldered together. The plate is then tried in the mouth and adjusted perfectly, any impingement upon movable tissues being relieved by trimming.

The rim is formed by soldering to the buccal and labial margins of the plate a platinum wire of special form obtained by means of a draw plate designed to produce it. In addition to furnishing a rim, this also reinforces the piece, and the form of the wire is such that a recess is left under its margin for the attachment of the porcelain body. It also permits the making of changes by trimming which may be subsequently necessary despite the most careful fitting of the plate when it is tried in the mouth.

The tube teeth are now ground and roughly adjusted to the plate A fine adjustment would be unnecessary, as the little spaces existing between the teeth and plate are easily filled in with the porcelain body. When the teeth are adjusted and the articulation is satisfactory, the teeth are secured to the plate with wax to maintain them in position. A plaster wall is formed over their external surfaces, the wax is removed and with a sharp pointed instrument passed through each tube the positions of the pins are marked upon the plate. The pins, of iridio-platinum wire fitting the tubes, are adjusted and soldered in place as indicated by the marks on the plate. The piece is now pickled and

washed thoroughly, after which the application of the porcelain is begun. A little porcelain paste is applied around each of the pins and the teeth are then forced over them into place. More paste is then added about the necks of the teeth, and the opening on the occlusal surface is closed in like manner. The teeth are now fixed in their respective positions by baking, usually two firings being necessary for this purpose. After the teeth are thus fixed, the various applications of body and enamel are made as previously described in the usual procedure.

REPAIRING CONTINUOUS-GUM DENTURES.

An objection formerly urged against the employment of continuous-gum dentures was the difficulty of repairing them in case of fracture. The validity of this objection could not be questioned when the old methods were in vogue, but now with a more precise knowledge of the materials at our disposal, and with the valuable acquisition to our armamentarium of the electric furnace, we are enabled to undertake opertions for the repair of these cases with the assurance of complete success.

When a case is presented for repair, before any other steps are taken, all foreign or extraneous material must be completely removed, not only from the free surfaces of the piece, but from the cracks and fissures as well. Any such material allowed to remain will exercise a deleterious influence upon the porcelain. The plate should first be scrubbed in water containing a little ammonia. To ensure effectually the further removal of the accumulations, the plate is encased in an investment of asbestos and plaster, placed over a gas stove, and gradually heated to redness. During this process the foreign matter is carbonized. After cooling slowly the plate is removed from the investment, washed with soap and water, and further cleansed with alcohol. It is then placed in the furnace and again heated to redness.

A detached fragment of a tooth, provided the line of fracture be distinct, may be readily replaced by the aid of liquid silex. The silex is applied to the broken surfaces, the fragment pressed to place, and the case heated in the furnace to an orange-red color. This gives a ready and quick method for this kind of repair which may be particularly useful in emergencies.

No attempt should be made to replace a broken tooth or teeth until the remaining portions are ground away. On the lingual surface the porcelain is removed until the platinum base or wire is exposed. The grinding on the buccal or labial surface should be sufficient to permit the proper replacement of the lost tooth. Teeth are selected of a mold and color to correspond with those remaining on the denture. They are ground to fit the spaces prepared for them, and at the same time are given a correct articulation. They are waxed in position and, if the length of the column of teeth to be replaced demands it, they are given a coating of shellac varnish and the piece invested to hold them in position.

This wax is removed, and the pins are attached to the plate as previously described, this time however, using pure gold as the connecting medium and the furnace as the means to fuse it. The unequal heating involved in soldering with the blowpipe would endanger the integrity of the porcelain. The case is allowed to cool, removed from the investment and cleansed. The body is applied and baked to the granular stage after which the enameling is done as before.

It is feasible to replace one or two teeth without attaching the pins to the plate with solder, the porcelain material alone maintaining them in position. In simple repairs of this kind it is only necessary to grind away enough porcelain to permit the tooth to be set in place.

The teeth may also be retained in proper position by adapting a platinum wire No. 30 around the plate to rest upon the labial and buccal surfaces of the teeth. The ends of the wire are engaged between or around the posterior teeth remaining on the plate.

If there is a break in the continuity of the platinum base and it is not extensive, it may be repaired by grinding away the porcelain immediately about it, adapting a thin piece of platinum plate to the break, and soldering it with pure gold in the furnace. The porcelain body and enamel are then applied as already described.

Cases sometimes present which after years of service cease to be useful because of the changes in the mouth incident to resorption of the process. In such a case it will be necessary to take a new impression, obtain dies and counter-dies and reswage the plate after removing the teeth and porcelain. This may be done by subjecting the denture to a red heat under the blowpipe or in the furnace and then plunging it into cold water. The porcelain will fracture and may be easily detached. All the porcelain portions of the denture may be effectually removed by immersing the plate in hydrofluoric acid for a few hours. After reswaging the process is the same as for constructing the original plate.

COMBINATIONS OF CONTINUOUS-GUM AND VULCANITE.

The ingenuity of the operator may find a fruitful field of employment in the various combinations of continuous-gum with vulcanite. The lightness, cheapness, and accuracy of adaptation of vulcanized rubber may at times be joined advantageously with the æsthetic qualities of porcelain.

Cases presenting extremely long bites in which the increased weight of the continuous-gum might prove objectionable, may with advantage be restored by such a combination. A cast of the jaw is obtained, covered with a base-plate of gutta-percha, and from the model so prepared, dies and counter-dies are made. A platinum plate No. 34, is swaged to cover the alveolar ridge, making no provision for the rim. The plate is perforated at various points, and through these perforations after the porcelain body has been applied, but before baking, retaining pits are made in which to engage the vulcanite.

The plate is warmed and set over the gutta-percha; the bite taken and the articulation of the teeth secured in the usual way. It is then separated from the gutta-percha, invested, and the teeth soldered to the plate or stays. The body and enamel are applied and baked. When this part of the denture is complete, it is set over a wax base-plate, the articulation adjusted, and the waxing process completed. The case is then flasked and the succeeding steps are analogous to those described in the Chapter on Vulcanite.

Continuous-gum sections or full pieces may readily be constructed and mounted in the vulcanite without the platinum base. Upon a base plate of wax, continuous-gum teeth are arranged and properly articulated. The labial and buccal contours are restored in wax; a coating of shellac is applied to the teeth and the case is removed and invested with the teeth downward in a horse-shoe shaped bed of investment material, half an inch thick, placed on a glass slab. The investment is built about the wax gum covering it to a depth of half an inch and extending well over its edge. The wax is thoroughly removed after the investment becomes hard. An iridio-platinum wire, No. 18, is adapted against the necks of the teeth under the pins bending the latter securely around the wire to maintain the teeth in place. That part of the investment previously covered by the wax is now oiled, and the porcelain paste packed in, applying it between and in front of the roots flush with the lingual surface of the teeth to take the place of the wax. The case enclosed in the investment is now introduced into the muffle with small pieces of pure gold applied to the junction of each pin. The gold solder unites the pins and wire and at the same time the porcelain body is baked.

When cool the case is removed from the investment and cleansed; given its enamel baking, and then set on the cast, waxed in proper position and the plate is finished in vulcanite.

CHAPTER XVI.

ARTIFICIAL CROWNS.

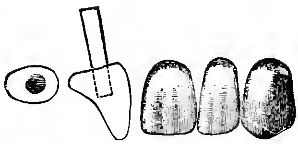
By H. H. Burchard, M.D., D.D.S., and F. A. Peeso, D.D.S.

When the crowns of teeth have suffered such extensive loss of substance that restoration by means of filling material is inadvisable, the restoration is an operation of prosthetic dentistry.

The term "artificial crown," as technically applied, includes only such devices as are made in the dental laboratory and subsequently set as a single piece upon a prepared root or remnant of tooth. The pieces known as "partial crowns" are also included in this category.

The first example of crown substitution, mounted according to the principles governing contemporary crown operations, was the setting of a crown of a natural tooth upon a prepared root, the support being afforded by a post extending from the enlarged pulp-chamber of such a crown into the enlarged canal of the root.

Fig. 591



Porcelain crown with wood post.

The mechanical principle involved in this mode of support has had constant application. The next variety of crown employed was that of porcelain, the post support being, as in the preceding form, a hickory post (Fig. 591.) Subsequently metallic posts were substituted for those of wood, and this variety is the typal form of one of the two great classes of crowns in present use.

Metallic crowns resembling those of the present day were employed early in the present century.

CLASSES OF CROWNS.

All of the varieties of artificial crowns may be divided into two great classes, according to their means and modes of support. The first class includes all of those crowns which depend for fixation upon a post anchored in an enlarged pulp-canal. (Fig. 592.) The second class includes those which have their retention secured by means of a continuous band encircling the neck of the root. (Fig. 593.)

Class 1 is subdivided into two orders; first, those in which the post is an integral part of the artificial crown, being baked in it or soldered to it (Fig. 592, *A* and *B*); second, those in which the post is firmly anchored in the pulp-canal, as a primary measure, and upon this support the crown itself is fixed as a second operation. (Figs. 592 *C*, 595, 596.)

A sub-order includes the collar and post crown (Fig. 592 *D*), the band

Fig. 592

A *B* *C* *D*

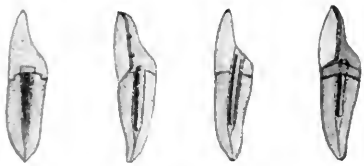


Fig. 593

A *B*

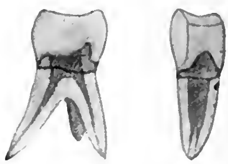
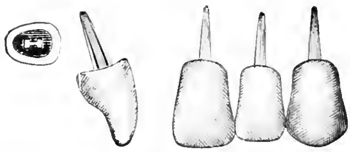


Fig. 594

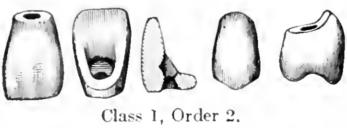


Class 1, Order 1,

encircling the root acting as a subsidiary support to the root, protecting it against fracture, the post being the retentive device proper.

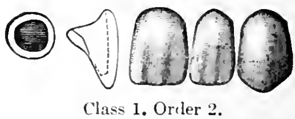
All of the artificial crowns in present use will be found to be a variety or some modification of one of these classes.

Fig. 595



Class 1, Order 2.

Fig. 596



Class 1. Order 2.

Each variety is designed and fitted to meet definite indications, and the application and choice of variety are determined by the anatomical, physiological, and pathological condition of the root to be crowned and, it may be, of the surrounding parts.

ANATOMICAL RELATIONS.

The first consideration is the position of the root to be crowned; and the second, its form. Its position includes the class of tooth, whether it be an incisor, canine, bicuspid, or molar; next, its relative position to its neighbors and to its antagonists, and what will be the relations of the artificial crown in these particulars.

Each class of tooth has a definite office to perform, and there is involved in the performance of its function an amount and variety of stress governed by the position of the tooth—*i. e.* the class to which it

belongs. This demands in the supporting structures of the crown and root sufficient resistance to secure the integrity of the crown and root in the performance of their normal functions.

Incisors by their positions and forms are designed to receive and resist stress in one direction, that tending to force them outward.

Canines in their normal relations receive stress in two directions: two forces act at an angle upon the axis of the tooth, and the resultant of these forces is a line outward.

Bicuspids are subjected to three stresses—vertical, outward, and inward; the relative amounts of stress are in the order given. The amount of the outward and inward stress is governed primarily by the lengths of the buccal and palatal or lingual cusps; the vertical stress, by the area of the occlusal surface.

Upon molars the vertical stress is greatest, and in the direct ratio of the extent of masticating surfaces; the lateral stress is governed by the lengths of the cusps.

Artificial crowns should be made of varieties to meet and resist the several directions of stress.

The line of greatest mechanical resistance in any root is in its vertical axis, and is the only line of stress which does not tend to displace the tooth mechanically. As to the vital resistance of a root, this rule is but partially true, for roots appear to rebel against stress in any other direction than that due to their normal anatomical positions.

In normal occlusion the stress upon any individual tooth is lessened or modified by the occlusion of the other teeth of a denture, so that the conditions of any tooth as part of a denture are not those of the same tooth standing alone. For example, the incisors normally receive a stress which ceases as soon as the molars and bicuspids are in perfect contact; in the absence of these latter teeth the entire force of occlusion falls upon the incisors, and they are unduly strained.

With the molars, the greatest stress being vertical, support is demanded from the entire root area underlying the crown. The latter represents primarily a block resting firmly upon a broad base. The lateral stress is guarded against by having one or two posts in the axes of the roots or by the periphery of the crown grasping that of the root-walls.

It is evident that the crown best adapted to meet these stresses is that having a barrel form, grasping firmly the periphery of the root; the retaining cement becomes mechanically part of the tooth, so that these crowns rest uniformly upon the entire area of the root-face.

Pin crowns of the variety placed upon bicuspid roots are occasionally employed upon molar stumps, but, as a rule, their intrinsic resistance is not as great as that offered by barrel crowns.

THE FORMS OF THE TEETH.

The great consideration as a governing factor in the placing of artificial crowns is the forms of the teeth. This includes the shapes and

sizes of the roots to be crowned as factors determining the type or variety of crown selected.

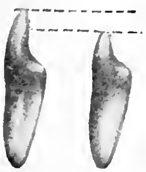
How does the area of root-section compare with the length of the root? And, again, how do these factors compare with the length and breadth of the occlusal surface of the artificial crown? For example two roots may have the same length and the same sectional area; one requires a crown half again as long as the other (Fig. 597), or the stress of occlusion may be more severe; obviously, the mechanical stress upon the root is increased in the ratio of the extent of its occlusion or the amount of increased leverage represented in the crown of greater length. Or, again, two roots having the same length, and artificial crowns of the same length and breadth, but the sectional area of the face of one root greater than that of the other, it is evident that the resistance afforded by the root of smaller section will be correspondingly decreased. A long heavy root will bear safely a crown which if set upon a short and narrow root and subjected to an equal stress would result in the loss of the root.

PHYSIOLOGICAL RELATIONS.

Under this heading are considered the vital conditions of the tissues of the teeth or roots and of their sources of nutrition and support; if the pulp be alive, what its condition; and whether it is possible or advisable to place an artificial crown without effecting the destruction of that organ. Teeth are occasionally broken in such a manner as to render restoration of form by filling material inadvisable, and yet not uncovering the pulp, the latter being healthy and the dentine normal. It is possible in some of these cases to adjust an artificial crown without destroying or disturbing the pulp; it is evident that modifications of the barrel crown are alone applicable.

Next, what is the texture of the dentine? Highly organized dentine will bear safely a strain which would injure dentine of poorer type. The latter type of tissue is non-resistant to the progress of dental caries, and thus needs protection against contact with or the access of the active causes of caries.

Fig. 597



The condition of the enamel rarely is a factor in the plans, except that faulty enamel, through its liability to fracture or crumbling, will sooner or later leave part of a natural crown or a stump for the attention of the prosthetist. It may be that a tooth crown consisting in large part of thin and discolored enamel is removed for æsthetic considerations and replaced by an artificial crown.

The Condition of the Pericementum.—This includes a consideration of the existing vital relations of this tissue, and the possible sources of irritation to it formed by the placing of an artificial crown, or acting after the crown is set.

PATHOLOGICAL RELATIONS.

As teeth which require artificial crowns have been brought to their condition by the action of pathogenic agencies, which if unchecked will ultimately cause the loss of the roots themselves, it is evident that these are the most important of the factors requiring attention.

The question of existing pathological conditions and their treatment belongs properly to the province of dental pathology and therapeutics; but the present subject is the common ground upon which the therapist and prosthetist meet: their offices are the two steps of a common operation.

If a tooth contains a vital pulp, and it is designed to retain that organ, the infected dentine, that invaded by the carious process, should be removed with the same care as though it were being prepared for the reception of a filling. Should the pulp be, or have been the seat of inflammation, it is destroyed and removed. If it is to remain alive, the same care is observed in guarding it against thermal shock as with fillings, so that after placing an artificial crown upon a stump containing a vital pulp there should be no increased response to applications of heat or cold.

When post crowns are indicated the pulp is to be, necessarily, destroyed.

The extent to which the carious process has invaded the dentine is a large factor for consideration, for the greater the loss of the dentine the weaker the root becomes, the less mechanical resistance it affords, so that support may be required to guard the weakened structure against fracture. Again, the more extensive the carious process the greater is the probability of such deep infection of the dentine that an increased length of time is required for sterilizing the infected tissue.

The present condition of the pericementum and its past history are the most important of all considerations. It is possible that a form of crown may be required which will permit of ready removal in case of recurring pericementitis; however, in a properly treated root such a contingency should be a remote possibility.

The liability or disposition of the pericementum toward inflammation may enforce a lessening of the stress brought to bear upon it through the artificial crown. It is a recognized principle of surgery, and never to be lost sight of in crown and bridge-work, that a part once inflamed has an increased tendency toward subsequent inflammation.

It is an inflexible rule that before the setting of an artificial crown the root bearing it must have such preliminary treatment that its pulp-canal and substance of its dentine are rendered aseptic, and if possible antiseptic, and the pericementum must be brought to a condition of health.

Unless the root be firmly fixed and supported by sound alveolar structures the following operations prove abortive just in the degree that the root is the subject of anatomical or physiological perversion. It must be remembered that the setting of an artificial crown places be-

yond access the most important means of combating disease of the crowned root, so that the assurance of continued root-health is a necessary preliminary.

PREPARATION OF ROOTS.

Under this heading are included, first, the therapeutic measures necessary to secure the continued health of all the dental tissues and their supports; and next the mechanical preparation necessary to form the root into a resistant base to which a crown may be fitted with exactitude.

PULP DEVITALIZATION.

When for any reason it is found necessary to devitalize the pulp of a tooth preparatory to the placement of an artificial crown, there are several questions to be considered. The first of these is, in which of the methods that may be employed, is there the least danger of irritation or injury to the retentive structures of the tooth? Second, in what way may the operation be done with the least pain to the patient? Third, how can it be most quickly and easily accomplished?

There are several methods and agents employed for the devitalization of the pulp almost any of which may be indicated under certain conditions. Among the agents usually employed for this purpose, arsenic is easily in most general use. It is the one which requires the greatest care in its use; is dangerous in unskilled hands, and is uncertain in its results both as regards pain to the patient and effectiveness. When its use has been decided upon the method advised by Dr. James Truman is recommended, and it will seldom be attended by pain if his directions are carefully followed. A very small quantity of arsenious acid is mixed with iodoform, using oil of cloves or carbolic acid as a vehicle and applying it to the exposed pulp on a small pellet of cotton. This is covered with a small cap of tin or aluminum, to prevent pressure on the pulp, and the cavity is sealed with gutta-percha or cement.

If the arsenic is applied directly to the pulp, it should be left in for a few hours only. If on opening the tooth again, it is found that it has not taken effect, another application may be made and this may be repeated if it is found necessary to do so. The action of the arsenic should not be permitted to extend all the way to the apex, but should be watched carefully and the pulp removed while there is still some life at its apical extremity. If there is no exposure it is safer to make the application only a little below the enamel, or in the bottom of an existing cavity, just sufficiently deep to be properly sealed in, rather than to make an exposure. The arsenic will act upon the dentine, to desensitize it, so that in a few hours it will be sufficiently obtunded to enable the operator to expose the pulp without pain to the patient,

after which, if he so desires, he can anæsthetize and remove the pulp by any method which he may see fit to employ.

It should always be borne in mind that arsenic or an anæsthetic will not act upon an inflamed or congested pulp. If the pulp is in this condition, a dressing of oil of cloves or eugenol and sulphate of morphia is one of the best applications for relieving the pain and reducing the inflammation. A pellet of cotton is saturated with the oil of cloves or eugenol and from one-fortieth to one-thirtieth of a grain of the morphia is added to it. This is placed in the cavity in contact with the pulp and allowed to remain until the pulp is quiescent, which will usually be in from twenty-four to forty-eight hours, after which the arsenic or the anæsthetic may be applied.

It is good practice not to use arsenic if it can possibly be avoided, as there is always a chance of disturbances following its use such as arsenical pericementitis or even necrosis. The former of these may not manifest itself immediately, but sooner or later it is liable to appear either in a mild or severe form. If the arsenic is not sealed in perfectly, especially if the cavity extends below the gingival margin, necrosis is likely to ensue, which in some cases might have far reaching effects. Some patients are peculiarly susceptible to this poison; and in the mouths of such, arsenic applied for a few hours only would be sufficient to devitalize the pulp completely, while in others it might remain for days or even weeks with seemingly little effect. In the former case, if it were left in the tooth for any great length of time, the chances are that its action would not be limited to the pulp itself, but would extend through the foramen and beyond the apex and involve the surrounding tissue. Especially would this be true if the foramen were somewhat enlarged. The danger would be greater when using it on a young, than on an elderly patient, as the root may not be fully developed, and the foramen may be widely patulous, in which cases, carbolic acid, creosote or some such agent is indicated. Cases also occur in which there is an imperfection in the walls of the root-canals. A condition of this kind is fortunately very rare as it is one which it is impossible to foresee and guard against, and if arsenic is used, disturbances which may result in serious injury to the patient are unavoidable. It sometimes happens that the pulp will resist the arsenic and repeated applications will have no effect, in which event, some other agent must be employed.

The safest and most rapid method is immediate devitalization by surgical means, either by anæsthetizing and extirpating the pulp at once with broaches, or by driving it out with a pointed orange-wood stick.

In employing the first of these methods, the following are the details of the operation.

The rubber dam should be applied to the tooth whenever it is possible to do so. If this cannot be done, napkins may be substituted to keep the secretions of the mouth from coming in contact with the field of operation. If a cavity exists through which the pulp canals are accessible or may be made so, it should be utilized. The instruments to be used should be ready at hand, so that they may be grasped instantly as

soon as they are needed. These should consist of broaches for removing the pulp from the canals, a large spear-pointed drill, large coarse rose burs, a large cross-cut fissure bur and one or two sharp spoon excavators. There are several effective instruments of the syringe type, strongly made and capable of exerting great pressure which have been designed for the purpose of obtunding or devitalizing with cocaine, but in the absence of one of these, a hand instrument and a piece of soft rubber may be used. The softened dentine should be removed from the cavity and if there is an exposure of the pulp, a crystal of cocaine hydrochlorate is placed immediately over it and a small pellet of cotton, not larger than a pin head, is saturated with one of the prepared local anæsthetic solutions or adrenalin chloride and placed over the cocaine. A solution of cocaine alone will render satisfactory results but seems more effective when used in conjunction with some other drug. A solution of formalin one part and alcohol five parts used with the cocaine crystals is favored by a good many operators. A piece of unvulcanized rubber, large enough nearly to fill the cavity, is put over the cotton and a burnisher or other instrument which nearly fills the opening of the cavity is used to press this tightly in, the pressure being kept up for about one minute. If the pulp is freely exposed, the anæsthetic may be injected directly into it with a hypodermic syringe, but this is a more painful operation and possesses no advantage over the method just described. After the pulp is completely anæsthetized and the rubber and cotton have been removed, the pulp-chamber should be freely opened with the rose or fissure burs so that there will be direct access to all of the canals. The body of the pulp may then be cut away with a coarse bur or a spoon excavator, after which that in the canals may be removed with broaches.

If it is a sound tooth which is to be devitalized, it is necessary to make a cavity for the exposure of the pulp. The actual exposure need be no larger than the point of a needle. In any of the six anterior teeth, this opening should be made on the palatal or lingual side, just above the basilar ridge and on a line with the pulp canal. The enamel at this point is very thick and hard and can best be broken through with small corundum or carborundum wheels or a diamond drill. The bicuspids and molars should be opened through the fissures and on a line with the centre of the tooth.

After breaking through the enamel, a large spear-pointed drill may be used to open into the pulp. If the engine is running rapidly and the drill is very sharp, the exposure may often be made quickly and with very little discomfort to the patient, but if the tooth is at all sensitive, the drilling should be stopped as soon as the patient experiences pain and the cocaine and pressure applied in the manner described above. This will prove an excellent obtundent for the dentine and generally one or two applications will enable the operator to open directly into the pulp. Another application can then be made to completely anæsthetize it, after which the opening may be enlarged and the pulp removed as already described.

In using the anæsthetic with pressure, the pulp is not devitalized of

course, but simply anæsthetized, and sensibility may return. In some of the multi-rooted teeth, where difficulty is experienced in getting into the canals, sensation may have returned to the pulp in one or two of them while the pulp was being removed from the others, and this would necessitate a second application; but generally one is sufficient.

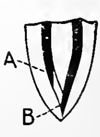
Ethyl chloride may also be used in making the exposure. In drilling the cavity when the tooth begins to be sensitive, the spray should be applied, intermittently at first, touching the tooth only for an instant, repeating at short intervals, each time keeping it on for a little longer period, until the tooth becomes insensible. In this way the tooth is cooled gradually and the pain or shock which occurs when the spray is applied directly and continuously is avoided. The spear-pointed drill is now used and if the tooth again becomes sensitive before the pulp is reached, the spraying is repeated.

In undertaking to remove the pulp, the operator should have an accurate knowledge of the anatomy of the teeth. He should know the number of roots which each tooth should possess, and just where to look for the entrance to the canals in the floor of the pulp chamber. Frequently some of these are very minute and hard to find, and a knowledge of their normal position is a most essential requisite in the search for them.

The mesial root of the lower molars is frequently very difficult to open. While there is but one root, in nearly every case there are practically two very constricted canals, a buccal and a lingual, which diverge or run parallel as they open from the pulp-chamber, but unite at or near the apex, making exit by a single foramen. (Fig. 598.) It is some times impossible to open both of these to their full length, but every effort should be made to get at least one of them clear all the way to me end of the root. For if one of the canals is opened to the apex and the foramen perfectly closed the pulp which remains in the other canal is entirely cut off, as in (Fig. 598, A and B) and the danger of subsequent trouble from it is very remote.

After one canal is filled, the remaining canal is saturated with chloride of zinc and filled as far as possible, so that only a little thread of coagulated pulp tissue is left in the root.

Fig. 593



The buccal canals of the upper molars also, are frequently so small that it is very hard to get into them for any distance. The twisted three sided broaches of the Kerr type are excellent for enlarging these constricted canals. A drop of sulphuric acid will very often materially assist the operator in opening them.

In teeth where the ends of the roots are bent almost if not quite at right angles to the rest of the root, it is impossible to remove all of the pulp. As much of this tissue as possible should be removed with broaches, following these with sodium and potassium or sodium dioxide, after which a dressing of one of the essential oils and aristol or iodoform may be placed in the canal which may be filled at a subsequent sitting

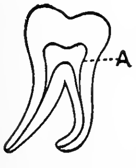
Occasionally the tooth may possess more or less roots than the nor-

mal number. In every case the pulp-chamber should be well opened and the floor and sides should be carefully examined with a fine explorer for the aperture of the canals. It is a mistake to undertake to remove the pulp with only a small opening in the crown of the tooth, especially if it is to be crowned. It does not weaken it to open it to the full size of the pulp chamber, as the crown of the tooth is only as strong as that part which has the least sectional area and this is at or near the floor of the pulp chamber, (Fig. 599, A), consequently the opening may be made to the full size of the floor of the pulp chamber without weakening the tooth in the least.

The third molars are especially lacking in uniformity as to the number of their roots, and the canals are frequently so small and tortuous as to render it impossible to open them more than a short distance. In such cases the operator must be satisfied with something less than the ideal results which he would desire so far as filling them to the end is concerned, but he should always be assured that they are at least perfectly sterile.

In employing the heroic method of pulp extirpation, the pulp must be well exposed. The end of an orange-wood stick is whittled to about the size and shape which the canal of the tooth is known to have, bringing the end down to a sharp point. It is laid within convenient reach, together with a small leaded mallet. If the crown of the tooth is to be removed, it may be cut nearly through by making a groove labially and lingually with a thin disk and then it is nipped off with excising forceps, using a chloride of ethyl spray if the tooth is very sensitive. If there is not sufficient exposure, the opening may be enlarged with a spear-pointed drill or a bud-shaped bur. The point of the orange-wood stick is then dipped in carbolic acid and placed at the entrance of the canal and a quick, sharp blow given it with the mallet. If it has been properly shaped, the pulp will be forced out of the canal beside the stick, or will be found clinging to it when the latter is withdrawn. If this does not occur and any of the pulp remains in the canal, it may be removed with the broach. The canal is then cleansed, sterilized and filled. This method is especially applicable to the single rooted teeth, but it may be successfully applied to the first bicuspids and under favorable conditions, even to molars whose crowns are so badly broken down as to render the canals easily accessible. In the upper molars, if the body of the pulp has been removed, that portion in the palatal canal may almost always be removed in this way, but the buccal canals are generally too small and difficult of access. In the lower molars, the pulp in the distal root canal may be extracted, but in the mesial, there would be the same trouble as in the buccal canals of the upper molars.

Fig. 599



If properly performed, this operation is as nearly painless as any method of devitalization. It is done so quickly that the pulp is paralyzed by the shock, and the pain should be no greater than that felt from the slight prick of a pin. This happy result depends entirely

upon the manner in which the operation is done, for at the hands of an awkard manipulator it might cause the patient a great deal of pain.

It has been the practice of some to devitalize the pulp in this manner and to fill the apex at the same time. The orange-wood stick is whittled to a fine point, and at a distance of from one-eighth to three-sixteenths of an inch from the end, a cut is made nearly through its substance with a sharp knife. The pulp is freely exposed, the point of the stick dipped in carbolic acid and driven quickly into the canal so as to wedge the end tightly in the apex. The stick is then twisted to break it off at the point at which it has been cut, leaving the apex filled with the orange-wood. It is very questionable if this is good practice. In the first place, the wood being pervious to moisture does not make a suitable filling material unless it is first saturated with some solution which will make it positively impervious. Again, should the foramen happen to be enlarged, the point might easily be driven through and beyond the apex, where it would act as an irritant and probably eventually be responsible for an alveolar abscess. Another objection to this method is the uncertainty of reaching the extreme apex with the pointed stick if the canals happen to be small and tortuous. In such a case the whole of the pulp would not be removed and the portion remaining in the canal beyond the filling might cause future trouble, and if the canals are tortuous, it would be impossible to remove the filling for treatment.

FILLING OF ROOT CANALS.

Satisfactory and permanent results in the filling of pulp canals is not so much a matter of the materials employed as it is the manner in which these latter are inserted. Of course, some of the materials in use are better than others, and it is probable that gutta-percha and oxychloride of zinc are the best.

An excellent method of filling with gutta-percha is as follows. As a preliminary measure to the operation it is understood that the rubber dam is to be applied to the tooth if this is possible, and if not, napkins are to be used to keep the field of operation dry. After the canal has been thoroughly cleansed and dried, a gutta-percha point is selected, of a size corresponding to that of the canal to be filled, and fastened to the end of a canal plugger by heating the point of this instrument. A little oil of eucalyptus is introduced into the canal from the points of a pair of pliers or with a wisp of cotton twisted around a broach. The gutta-percha point is now dipped into oil of eucalyptus and then the tip of it into iodoform or aristol, after which it is placed in the canal and worked into it with a pumping motion, carrying it farther up as the oil softens the gutta-percha, until it becomes loosened from the plugger and is packed tightly into the root. In this way the canal can be as thoroughly filled all the way to the apex as by any method. It does no harm if the patient winces a little during the operation, as that is a pretty good indication that

Fig. 600

the end of the root has been reached. Chloroform may be used in place of the eucalyptus, but the oil is preferable as it is of a healing, soothing nature, besides possessing antiseptic properties which persist in the canal for many years.

If the foramen is enlarged, care must be used not to force the filling beyond the apex. A canal plugger should be used which is large enough to wedge in the canal while it is still about one-eighth of an inch from the apex and the size of the point carefully judged so as to fill just to the end of the root. (Fig. 600.) When the canal has been enlarged to receive a pin, a short point is attached to the plugger, dipped in the eucalyptus and iodoform or aristol, carried to the apex and packed tightly against the shoulder left by the reamer.

When chloro-percha is used as a filler, a little iodoform or artisol is first put in the canal and the chloro-percha pumped in with a broach, a fresh supply being added as the chloroform evaporates. When it is carried well into the canal a gutta-percha point may be forced into it, or fine wisps of cotton may be packed in with a small plugger, until the canal is filled. It is questionable if this will make as perfect a filling as the gutta-percha point, especially in the upper teeth.

The objection to oxychloride of zinc as a root filling is the irritating nature of the zinc chloride and the difficulty of limiting its action. If a little of it is carried beyond the apex, it will cause considerable pain and discomfort to the patient, and may sometime result seriously. Another objection to using oxychloride alone, especially in any of the teeth anterior to the molars, is the difficulty of opening up the canals at some future time for the reception of a pin, should it become necessary to crown the roots. This difficulty, however, may be overcome: after the canal has been pumped full of liquid cement, a gutta-percha point is inserted and forced to the end of the root.

Paraffin is also used as a root filler. A little iodoform or aristol is first placed in the canal and the paraffin carried into it with a fine heated broach. This makes a good root filling, especially in the lower teeth.

PERFORATED ROOTS.

This is a difficulty which is frequently encountered, and the treatment of it is often very puzzling to the dentist. Where the perforation is at the apex, it may be treated and the root filled in the same way as an abscessed tooth where the foramen has been enlarged. If there has been much inflammation, a dressing of one of the essential oils and iodoform or artisol may be kept in the canal until the soreness has passed away, when the root may be filled in the manner already described. Where the perforation is of long standing, the root will probably be abscessed and the treatment of the case would come under the head of alveolar abscess.

Where the perforation is at the side of the root, it is quite likely that the soft tissues have grown into the cavity. This intruding tissue may

be removed by excision, or it may be cauterized with trichloracetic acid, carbolic acid or iodine. Where the size of the growth is not great, the opening may be cleared by packing the pulp cavity tightly with dry absorbent cotton. This will expand as it becomes moist and force the gum tissues out. The sides of the opening should now be grooved or roughened so as to hold the filling in place, and the cavity is then wiped out with adrenalin chloride. If the perforation is not far below the gum margin, it often happens that a small flat-ended instrument may be passed under the gum and up the side of the root so as to cover the opening. If this be possible the instrument is held in place against the root, the cavity dried thoroughly, and the filling packed tightly against the instrument.

Where the perforation is so far beyond the gum line that it is not possible to cover it, a little base-plate or high heat gutta-percha is pressed into it and then removed. This will show the exact size and shape of the perforation. If gutta-percha is to be used to stop it, the trial plug is trimmed so that it will come not quite to the outer wall of the root, leaving a slight excess on the inside. Adrenalin chloride will prevent blood or moisture from oozing into the cavity, which should be dried with alcohol and then wiped out with oil of eucalyptus or any other essential oil. The plug, which has previously been lightly fastened to the end of an instrument, is then placed in the opening and packed flush with the canal wall.

Copper amalgam is one of the best filling materials for cases of this kind. In the one just described, the trial plug will show the amount which it will be necessary to use and the amalgam is packed into the opening, care being used not to force it beyond the outer wall of the root.

Where there is a large perforation in the floor of the pulp chamber, it is better first to cover it with a piece of thin, soft platinum and then to fill the chamber with copper amalgam, keeping the entrance to the canals free.

FRACTURED ROOTS.

This is a troublesome condition of somewhat frequent occurrence, and it is often difficult to decide whether a root which has been split can be saved or will have to be extracted. The fracture of a root is often brought about by crowning without banding it and is most frequently either that of an incisor or a bicuspid. In the majority of cases where there is a bad fracture it will be necessary to remove the root but sometimes it can be made to do good service for a number of years even if it has been split all of the way to the apex. Where the root has been newly fractured and the gum tissue has not had time to crowd its way between the broken parts, they should first be drawn close together by placing a strong wire of 30 or 32 gauge over the stump and twisting it tightly in the same way as in taking the measurement for a band. It should be forced up on the root as far as possible and if necessary, the

gum can be slit on the labial side to allow of its being carried to a sufficient distance under the gum. The root can then be prepared, a tightly fitting band made, and the crown constructed and cemented to the root. After the cement has thoroughly hardened, the wire ligature is to be cut away, and if the band has been properly fitted, the tooth should last for many years.

Another way to preserve these roots is, after the parts have been drawn together, to cement a narrow iridio-platinum band on the root, then to proceed to make the crown as if the root were perfectly sound.

In many cases where there is only a minor fracture, the part which is broken away may be removed and the band carried beyond the line of fracture.

TREATMENT OF CONDITIONS RESULTING FROM INFECTION OF THE PULP.

If the pulp be the seat of purulent inflammation or of moist gangrene, it should be removed, so that none of the pathogenic organisms may be forced into the tissues about the apex. The root and the degenerated pulp-tissue are filled with a strong penetrating antiseptic, such as meditrina (a solution of hypochlorites), and this is permitted to exercise its properties before the broach is applied. It is a wise precaution to wash the mouth well with this solution prior to opening any pulp-chamber in which there is putrescible material. When possible, the rubber dam is applied, the cavity dried, and a strong solution of sodium peroxide carried into the canal, gently stirring it with an iridio-platinum broach: as soon as effervescence ceases, wash out the canal with sterilized water, and repeat the applications of the peroxide until access is had to the apex of the root.

The dentine of roots which have contained gangrenous pulps is the seat of more or less albuminous decomposition, so that ample time should be taken in sterilizing it. Sodium peroxide, is the agent to be preferred, as this substance is itself decomposed into sodium hydrate and free oxygen; the former saponifies the fatty products of decomposition and dissolves the protoplasmic filaments; the oxygen mechanically drives out the dissolved materials, and effectually destroys any organisms present.

If there be no exudation from the apical tissues into the canal, it is good practice to dry out the canal by means of alcohol and hot blast, and fill the apical portion of the canal with a gutta-percha cone which has been covered by an antiseptic oil—cajuput, cinnamon, cassia, or eucalyptus, and then dipped into aristol or iodoform.

Should the apex of the root be the seat of an abscess, this is to be cured before the apical foramen is sealed. The canal is washed out with the sodium peroxide, and cleansed thoroughly: no harm is done if the solution be forced through the root. Succeeding this, a solution of caustic pyrozone is pumped through the canal into the abscess-sac until the

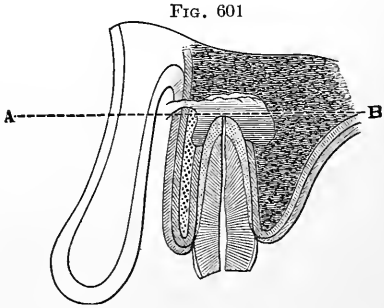
pus is driven through the fistula. As a rule, these roots may be filled at once, and the abscess-sac is soon obliterated by the formation of new tissue about the apex of the root. It occasionally happens that the fistula does not close after one injection, so that as a precautionary measure the permanent hermetical sealing of the apex of the canal is deferred until it is seen that the fistula heals and the normal color of the gum over the affected tooth is restored.

Cases present at times which give a history of a fistula alternately healing, then opening. Even after repeated injections the fistula will open periodically, and a discharge of pus or serum occur. A condition is present at the apex of the root which demands removal by amputation of the apex. Before the pus formed at the apex of a root makes its escape through a fistulous opening in the gums the destruction of tissues incidental to or characteristic of abscess proceeds in all directions, so that by the time a fistula is established the end of the root is extending into an irregular cavity, the pericementum destroyed for some distance above the apex, and the uncovered portion of the cementum saturated with noxious material. When the pus above the dotted line (Fig. 601) discharges, the fistula may heal, and remain closed until an increased pus-formation again re-establishes the fistula.

The gum is to be divided above the apex of the root, the pericementum is scraped from a small area, and free entrance is gained to the abscess-cavity by means of sterilized burs. As soon as the bleeding is checked a fissure bur is passed through the opening and the denuded portion of the root cut off and rounded. The sterilization of the canal and its filling have preceded the amputation.

In what are known as blind abscesses, those without a fistulous tract leading from them and discharging externally, it is advisable where possible to make an artificial fistula. The mouth is sterilized and a crystal of cocaine placed on the gum over the apex of the root. The length of the root is measured by a broach in the canal, and this length measured on the gum over the root. A crucial incision is made through the gum, the bone denuded of periosteum over a small area, and a spear-pointed engine drill is quickly passed through the bone and into the abscess-cavity. The case is treated then as a simple abscess. The operation may be made almost painless by injecting a few minims of a 4 per cent. solution of cocaine. The canal is filled after a thorough sterilization, and pending the healing of the abscess-cavity, the external opening is kept patulous by means of a couple of strands of floss silk acting as a tent and means of drainage.

Fig. 601



Persistent endeavor should be made to enter freely and cleanse out perfectly to the apex all the fragments of pulp-tissue in the roots of

teeth, even in the most minute canals. The introduction of the use of sulphuric acid, in connection with broaches, for gaining entrance to, enlarging, and cleansing canals, by Dr. J. R. Callahan [1], has added to the operations of dentistry a most valuable expedient, and furnishes a means for the removal of a common cause of apical pericementitis, imperfect removal of pulp-fragments. A drop of a 50 per cent. solution of sulphuric acid is placed over the mouth of a fine canal, and pumped into it by means of a fine Donaldson broach.

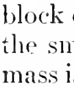
Much patience will be required to effect the desired end in some teeth, but so long as there is an imperfectly cleansed canal there is the ever-present fear of the possibility of abscess, and if the crown be properly set, it is most difficult to cure the diseased condition.

Roots or teeth which have a portion of their surface overgrown by a hypertrophied gum-tissue must have the latter removed, so that the field of operation may be open. If it be a pendulous mass, the gum is excised sufficiently to free the root outline. If the margins of the root be covered by the gum, it is to be pressed back until the field of operation is free. The canal and the pockets beneath the gum margins are washed out with meditrina and the canal and face of the root dried. A block of temporary stopping is made and formed into a truncated cone, the small end of which is pressed against the face of the root and the mass is flattened so that it presses the gum away from the root on all sides. "Should there not be sufficient concavity in the root to hold the stopping, a large-headed carpet tack may be pressed into the canal and the gutta-percha wedge built around the post." [2]

MECHANICAL PREPARATION OF TEETH AND ROOTS.

The vital relations of the teeth or roots having been satisfactorily settled, the success of either crowns or bridges depends more largely upon the proper preparation of their abutments than upon any other mechanical factor. If these are not properly prepared, the results will be disappointing to both dentist and patient, however well the prosthetic portion of the work is done. A large proportion of failures may be traced to this source and too much care and study cannot be given to the subject. Other parts of the work might perhaps be slighted without seriously affecting the permanency of the operation, but lack of proper preparation of the abutments will aways be at the expense of the permanence and safety of the fixture. The trimming of a tooth may seem to be a simple operation, but it is not. It takes time to do it properly and this time must be given.

FIG. 602



We shall undertake to describe in detail the preparation of the teeth and shall begin with those which are to receive full gold crowns, either

[1] Dental Cosmos, vol. xxxvi., p. 329.
[2] W. H. Trueman.

single, or as abutment pieces for bridge-work. We shall take first the lower molars.

Viewed from the buccal side the approximal contour of these teeth is very great. Starting just below the gum line, it swells outward, until at the point of contact with the adjoining teeth, the tooth is from one-quarter, to one-third larger than at the neck. Viewed from the occlusal surface, the tooth is oblong in shape.

This tooth when properly trimmed, is nearly square in shape, with the corners rounded, being slightly broader on the mesial side and nearly flat, while on the distal side, it is somewhat convex. This is owing to the difference in the size and shape of the two roots. The buccal and lingual sides are nearly straight lines, with a slight depression near the middle, from the bifurcation of the roots. (Fig. 602.) This description will apply more especially to the first and second molars, the third molar being subject to greater variation in shape than the others.

The lower molars are, perhaps, the most difficult teeth in the mouth to trim. The bulk of the cutting in these, as in all of the teeth, will be on the mesial and distal surfaces, the contour being greatest at these points. This contour must be entirely removed to a point about one-sixteenth of an inch below the gum line, so that when the band is passed over them, it will hug the neck of the tooth tightly. For doing this work cup or saucer-shaped disks, either diamond, or thin corundum, or carborundum and rubber, are best adapted. (Fig. 603.) The tooth is examined with an explorer to determine how much of the contour it is necessary to remove. The edge of the wheel is placed at the proper point on the occlusal surface and the whole of the contour is to be taken away with one cut, using plenty of water and holding the wheel very steady. (Fig. 604.) If it is found that there is still some projection at the cervical margin, it may be removed with the face of the wheel.

For the buccal and lingual sides, when using the straight hand-piece, a thin flat disk, or an inverted cone, either of diamond or carborundum, may be used. These should be from three-eights to five-eights of an inch in diameter.

The most of the cutting here, will be on the lingual side, as these teeth generally incline toward the tongue. The trimming of these surfaces may be most easily done from the side on which the tooth to be trimmed is located. If it is on the right, the operator should stand on that side, if it is on the left, he should stand at the left of the patient. The buccal side may be ground with the face and the lingual with the reverse side of either the flat wheels, or inverted cones. (Figs. 605, 606.)

The anterior buccal corner may be nicely rounded to the desired distance under the gum, with the inverted cone or disk, using the face and rotating from side to side as in Fig. 605. The posterior lingual corner is reached with the reverse side of the same wheels (Fig. 607), while for the posterior buccal, the inverted cone must be used from the opposite side of the mouth.

FIG. 603

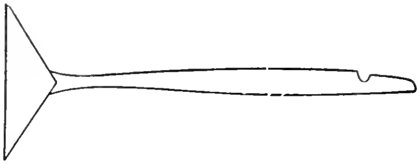


FIG 604

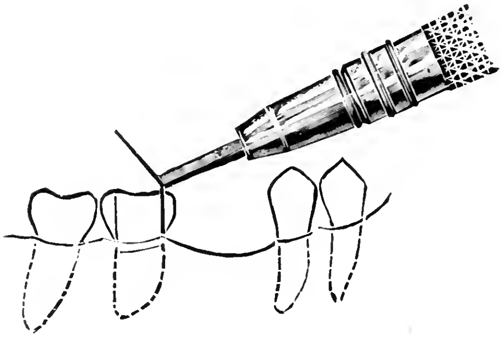


FIG. 605

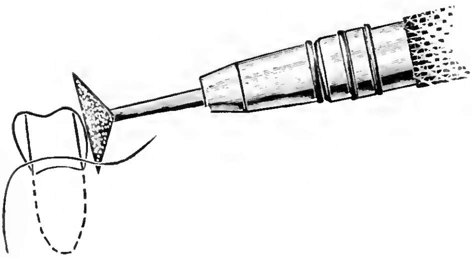


FIG. 606

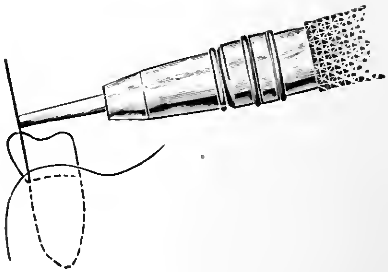


FIG. 607

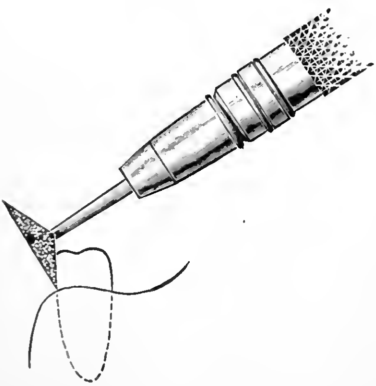
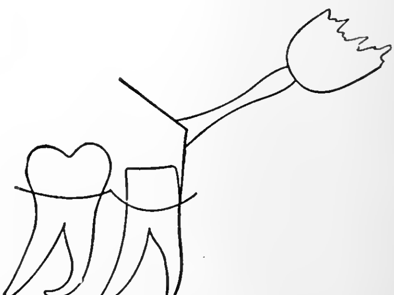


FIG. 608



The anterior lingual corner is the most difficult of any to reach, but most of this may be taken away with the face side of a saucer-shaped wheel, rotating it from the opposite side of the mouth. (Fig. 608.) Very coarse emery-cloth disks on account of their flexibility are of great use in finishing these corners.

With the right angle hand-piece, small diamond disks from three-eighths to five-eighths of an inch in diameter will be found very useful, especially for the corners. In some places which cannot be reached with wheels or disks the corners or ledges may be removed with enamel cleavers or scalers. The No. 3 S. S. W. scaler, or the same scaler with one safe edge, made in rights and lefts, may be used. The explorer should be constantly employed to detect the slightest irregularity or projection of the surface by sliding it down the face of the tooth, and the least shoulder or ledge must be removed, so that when the band is passed over the tooth and under the free margin of the gum, it will hug the neck tightly. A fissure bur or a finishing bur may often be used to advantage for locations which it is almost impossible to reach with any thing else.

In the lower jaw where the first molar has been lost, it will generally be found that the second has pitched forward so that its only point of contact with the upper teeth is at one of the distal cusps. In cases of this kind there will be little or no cutting on the distal side of the tooth: but on the mesial side at the masticating surface, it would be necessary to cut far back toward the centre of the tooth in order to make it nearly parallel with an anterior abutment as in (Fig. 609.) The cup-shaped disks are used here as in the former cases. The lingual and buccal sides and the corners are to be treated in a manner already described.

Where there is an excessive leaning of the tooth toward the tongue, as in Fig. 610, there will be no cutting at all on the buccal side, but a

Fig. 609

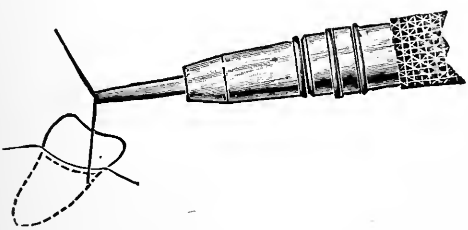
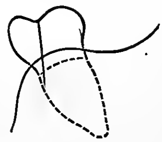


Fig. 610



great deal on the lingual, the most of which can be done in one cut with a thin disk.

It is far better to trim too much than too little. If a tooth is cut away more than enough to remove the contour, the band can rest on the ledge or shoulder and the cement may be entirely removed, so that there will be no irritation, but if enough has not been taken away, when the crown is in place, the band will cut into the gum and the cement presents a

rough, jagged surface to the soft tissues, causing irritation and inflammation which will eventually result in the loss of the tooth.

The bicuspids are trimmed in the same manner as the molars, but in most cases a straight or flat disk may be used on the mesial and distal sides. The point of difficulty here as in the molars, is the mesio-lingual corner and this will have to be trimmed largely with the scaler.

At the masticating surface of the teeth enough tooth structure should be ground away to permit the placing of a strong thick cusp, especially where it is to serve as a support for a bridge. This can best be done with a very coarse grit square-edged wheel.

The shape of the upper is very different from that of the lower molars. Observed from the masticating surface, they are somewhat diamond-shaped with the corners rounded, the greatest diameter being from the anterior buccal to the posterior palatal corner. (Fig. 611.) This is generally the shape of the third molars, but these teeth are subject to more frequent variations in form than the others of the upper series.

The typical form of the upper molars, after being prepared, is not at all like that of the lowers. It is somewhat triangular in shape, with the long dimension on the mesial side. (Fig. 612.) It is broader at the buccal side than at the palatal, because there are two buccal roots and but one palatal. This shape may vary at times and the palatal be as large or even larger than the two buccal roots, but this is an abnormal condition and will be readily discovered by the use of the explorer.

It infrequently happens that the first or second molars will have but two roots and when this is the case, they will both be of about the same size. Very rarely they may have but one root. The third molars are more uncertain, as there may sometimes be but one at other times several roots.

The trimming of these teeth is much easier than that of the lower molars. The bulk of the cutting will be on the mesial and distal surfaces, the greater part of which can be taken away with one cut of the disk already described. For the buccal and palatal surfaces and for

Fig. 611

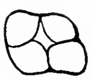


Fig. 612

Fig. 613

the corners, the cup-shaped disks and inverted cones are indicated. The coarse emery cloth disks will be found almost invaluable in rounding the corners, especially the posterior buccal and palatal.

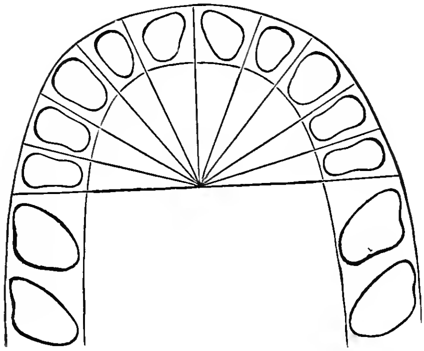
The bicuspids are trimmed in the same manner as the molars. These teeth after being prepared are somewhat egg-shaped, in cross section, being long and narrow from buccal to palatal side, broader at the buccal and having slight depressions on the mesial and distal sides. (Fig. 613.) This description applies chiefly to the second bicuspid, as it is seldom that a full gold crown, on account of its conspicuousness, should be placed farther forward in the mouth than that tooth.

We now come to the eight anterior teeth. All crowns for these teeth should be of porcelain or porcelain faced. The method of their preparation to receive a band is somewhat different from that of the other teeth, the work being done almost entirely with enamel cleavers and scalers.

The typical shape of the roots in the upper jaw, anterior to the molars, the centrals excepted, after being prepared for the reception of the band, is oval, being broadest at the labial side and narrow at the palatal. This must of necessity be the case, in order that they may be properly accomodated in the arch. (Fig. 614.)

The first bicuspid has very much the same shape as the second. The shape of the canines and laterals is almost a true oval, but the central

Fig. 614



roots while of the same general ovoid form, are more distorted, being somewhat triangular in shape. The longest side of the triangle is on the mesial and the shortest on the distal side of the root. The labial side is somewhat flattened and generally inclines outward toward the median line.

Fig. 615

Fig. 616

Fig. 617

In preparing these teeth, they should be left about one-sixteenth of an inch above the gum line until after the root has been trimmed and the band has been fitted. It will be found that the greatest sectional area of the root of these teeth is at the point of junction of the enamel

with the dentine. (Fig. 615.) The enamel must be entirely removed, and if this is properly done, unless there has been a recession of the gum, the root will be of the proper shape for the reception of the band

FIG. 618

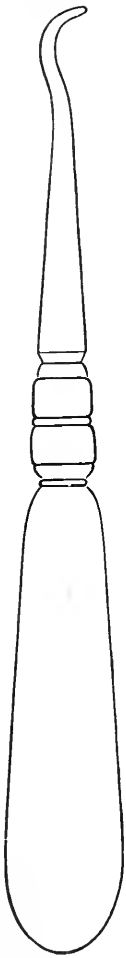
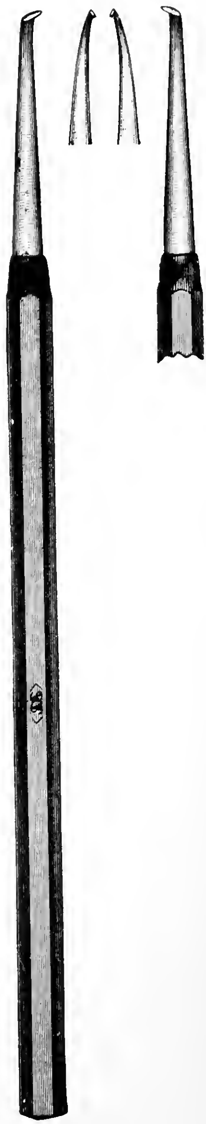


FIG. 619

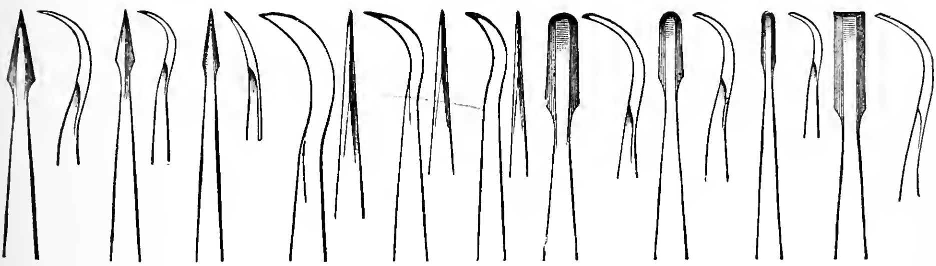


(Fig. 616), which should take the place of the enamel and fit the root tightly.

For removing enamel, the enamel cleavers (Fig. 619), and scalers

are best adapted. On the mesial and distal sides the thin disks may often be used to advantage. For the labial and palatal sides, the No. 3 (S. S. W.) scalers are the best (Fig. 618), as the curve of the instrument adapts ~~itself~~ nicely to the root. These instruments should have short heavy handles so as to afford a sure grip for the hand, and should be held in such a guarded and protected manner that there will be no chance of the instrument slipping and injuring the soft tissues. For the approximal sides, where the teeth are very close together, the No. 7 (S. S. W.) scaler (Fig. 620) will be very useful. At the basilar ridge, where the enamel is very thick, the enamel cleavers can be used to start it, afterward finishing with a No. 3 scaler. Where the gum has receded beyond the edge of the enamel, the root is trimmed in the same manner, the sides being made parallel or slightly convergent.

Fig. 620



The root of the lower anterior teeth are the same general shape as those of the upper, with the difference that the bicuspids are narrower bucco-lingually and the incissors are flattened mesio-distally. These roots are trimmed with scalers in the same manner as the upper teeth.

SHAPING THE FACE OF THE ROOTS AND ENLARGING THE CANALS.

The further preparation of a root in the anterior part of the mouth, after the enamel has been removed, varies according to the style of crown which is to be used. In any case where the root is to be banded, it should be left standing about one-sixteenth of an inch above the margin of the gum until after the band has been fitted. For taking the measurement of the root, Kirk's dentimeter is the most suitable instrument. The wire is placed over the end of the root and forced as far under the gum as is possible and twisted until it hugs the root tightly. It is then removed, the loop cut, the wire straightened out and the band cut to the measurement and united either by sweating or soldering. It should be festooned to follow the gum line perfectly, so that it will go an equal distance below the margin all around. After the band has been fitted, it is removed and the root cut to its proper length. It should be cut at least one thirty-second of an inch and in many cases,

nearly or quite one-sixteenth of an inch below the gum line on the labial or buccal side, so that when the crown is placed on the root, the band will be completely hidden. (Fig. 621.) Where a Richmond crown is to be used, the root is left standing out from the gum on the palatal or lingual side as in Fig. 621. If porcelain is to be used, it is necessary to have as great an amount of body as possible to give strength to the crown, this being of necessity a very fragile material. In this case the root should be cut so as to follow the line of the septum of the alveolar process, leaving it higher in the centre and low both labially and lingually as in Fig. 622.

In opening up the root for the pin, if it is enlarged on a line with the canal, the pin will in most cases come wholly or partially under the facing (Fig. 623), necessitating the cutting of the facing to accommodate it, or if the facing is to set close to the floor, which is desirable in the six anterior teeth, the cutting away of the end of the pin, so that the only attachment it will have to the crown will be to the thin floor of the cap, as in Fig. 624. This applies more particularly to Richmond crowns on the six anterior roots, either single or those to be used as abutment pieces for bridges. The better way to do is, after the canal has been enlarged in a direct line, to incline the reamer toward the palatal side of

Fig. 621

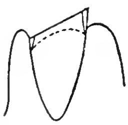


Fig. 622

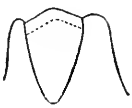


Fig. 623

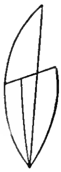


Fig. 624

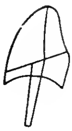


Fig. 625

Fig. 626

Fig. 627

the root, thus sloping the canal in that direction. Now by bending the pin slightly, there will be ample room in front of it for the facing, the pin coming up behind it as in Fig. 625.

For porcelain crowns, the root should be enlarged only on a line with the canal, especially in the upper jaw where the strain is all outward, and the facing grooved to receive the pin, so as to have as great an amount of porcelain on the palatal side of the crown as possible, to give the needed strength. (Fig. 626, 627.) In the lower jaw where the strain is inward, the pin may be set farther in toward the lingual side of the root.

REQUISITES OF A CROWN.

Artificial crowns should, as nearly as possible, restore the appearance and function of the natural teeth. Moreover, by their presence they should afford no more opportunity for the action of disease-producing agencies than when a natural crown is upon a pulpless root. This rule is impossible of exact fulfillment, but it is possible that by a correct artificial crown, properly placed upon a healthy root, the possibilities of disease processes arising may be reduced to a minimum and by an

improperly made or placed crown the probabilities of subsequent disease are increased.

All crowns must rest firmly upon the face of the root upon which they are placed. The contact must be at all points of the edge of a crown with the tooth surface. If of porcelain, it must correspond in shape, size, shade, and position with its fellows, and must subserve the purposes of a crown in mastication.

There should be at no part any projection which can form part of a pocket, nor any point which can act as an irritant to vital tissue. The line of junction between tooth and crown should be clean and clear, so that neither the surface of the root projects beyond the edge of the crown nor the edge of the crown beyond that of the root.

If a barrel or collar crown, the gingival edge of the collar or barrel must be in close contact with the root surface. It should extend far enough beneath the margin of the gum to grasp the root firmly, but should not extend to the alveolar border. A limited portion of pericementum is destroyed in trimming a root, and the collar should not extend beyond this point, as the collar represents or replaces the upper border of enamel, it should not extend much beyond the depth of the enamel line unless the gum should have receded from about the tooth.

Porcelain crowns should have the porcelain protected against fracture, either by the inherent strength of all porcelain crowns themselves, their bulk supplying the strength required, or, if a porcelain facing, the facing should be protected by a metallic backing against the force or shocks of mastication.

For posterior teeth the details as to correspondence of size and contour are equally important, and in addition their articulating surfaces should have such an arrangement of cusps and sulci that the normal masticating surface is restored.

TYPE SELECTED.

As a general rule, no root anterior to the second bicuspid should be crowned with an all-gold crown. None of the incisors or canines should show any but a porcelain surface. Healthy roots which have not been invaded by caries, if of good size and structure, as a rule, may be fitly crowned with some form of the pin crown.

Logan crowns are adapted when the root is of good structure and when form and color corresponding exactly to the adjoining tooth can be had, and when the bite is not too close to cause weakening of the porcelain by the necessary grinding, and where the correct cervical surface outline can be had.

THE POST AND PLATE CROWNS.

These are crowns which have posts fitting the enlarged pulp-canal for support. The proper size and shape of this post are about those used in the familiar Logan crown.

A root which has lost no substance, or no more of the periphery of

its pulp-canal than will receive a post of this size, is usually a fit root for the application of a post crown. Should there be a loss of substance in excess of this amount, a supporting band is advisable.

The size of the post may also be had in a flattened wire of 14 B. & S. gauge and somewhat tapered toward its extremity. The flattening increases the resistance in the long diameter, which occupies the antero-posterior line of the pulp-chamber, the line of greatest strain. Round and square posts are needlessly strong for one diameter, insufficiently so in the other. When the pin is double, as in bicuspids and molars, round or square pins may be employed.

The old type of post, the wood pivot, has been so entirely superceded that it scarcely needs description. These crowns were anchored by means of round hickory sticks, which were compressed immediately before using. A suitable crown selected was ground to the root face, the compressed wood set in its base, and then the post was thrust into the enlarged pulp-canal. Roots have been split, frequently, through the swelling of the compressed wood.

Fig. 628

Fig. 629

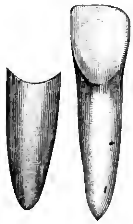


Fig. 630

A form of made-up post crowns commonly employed is selected as the typical form; it is the pin and plate crown. A detailed description of this will serve to illustrate many of the principles governing the making of all crowns.

The method of making is as follows: an incisor or canine root which is in a perfectly healthy state is thoroughly sterilized, and the apical foramen hermetically sealed by some unchangeable material which has been coated or saturated with a strong antiseptic; usually a gutta-percha point is used for this purpose, one which has been soaked in one of the antiseptic oils.

The pulp-canal is enlarged for about two-thirds its length, in such shape as to receive a flattened pin of iridio-platinum wire of No. 14 B. & S. gauge, which is to fit the enlarged canal easily enough to permit ready removal.

The face of the root is shaped to follow the outline of the gum margin, and to have its surface about a line below this margin (Fig. 629.) At its anterior aspect the cutting should be a trifle deeper than at the other parts, to ensure perfect hiding of the joint. The operator may now, if he prefers, take an impression of the face of the root, and fit the root-plate on a model prepared from it. An effective method is as fol-

lows: after shaping the post-canal and face of the root and fitting the post, Melotte's moldine is placed around the pin, covered by damp tissue-paper, and inserted in the root; an impression in moldine is then taken; after removing from the mouth the post is withdrawn and placed in position in the impression, and a die of fusible metal made. Should the paper and moldine be scraped from the post in removing it from the canal, it is to be again covered by moldine enclosed in the paper before placing it in the impression.

The thin layer of moldine covering the post permits its withdrawal from the die. A small piece of soft platinum plate No. 31, or of 24-carat gold plate No. 30, is well annealed and placed upon the root face represented on the die, and pressed into rough adaptation (Fig. 628): a piece of erasing rubber answers well as an elastic counter-die for this purpose. A buckshot or a small piece of soft lead is placed over the root face on the die, and struck with a hammer until it is fit to serve as a counter-die.

The small plate, again annealed, is placed between die and counter-die and swaged with a light hammer. A hole is made in the plate to uncover the root opening, small enough to require force in pushing the post through it, so that the post, when in position, is closely embraced

Fig. 631

Fig. 632

Fig. 633

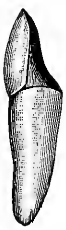
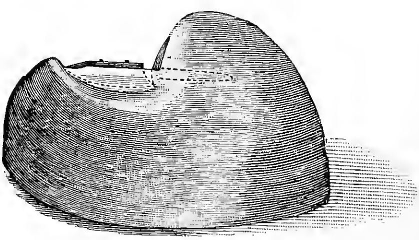


Fig. 634



on all sides. The post is then withdrawn, the plate coming with it; borax is applied at the line of junction, and if the plate is platinum it is soldered with a small piece of 24-carat gold, or, if the plate be of gold, with a minute piece of 22-carat solder. The plate is then trimmed to follow the root outline; at its labial aspect it is filed to a thin edge (Fig. 630.)

The post and plate are placed in position on the natural root, and with an orange-wood stick and a light mallet tapped at all points until the adaptation is perfect.

A bite of wax which includes the adjoining teeth is now taken, removed, and chilled.

Next a plaster impression is secured, in which are withdrawn the post and plate; if not withdrawn in the impression, a depression is seen, in which the top of the pin is inserted.

A shade tooth is selected at this time. The impression is double varnished with thin shellac and thin sandarac, allowing each varnish to dry well. Pins are placed in the impressions of the teeth adjoining the root to be crowned, and poured carefully with rather thin plaster, to be

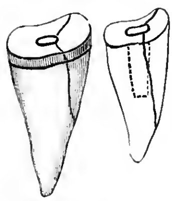
sure the impressions of the tips of the teeth are perfectly filled. Let this set well before separating the cast from the impression; place the wax-bite in position on the model, and make an articulation on a crown articulator.

Varnish with thin shellac the teeth of the casts.

Saw off the protruding end of the post to within one-sixteenth of an inch of the plate; the anterior edge of the post may be beveled even with the plate; removing more than this weakens the post attachment to the plate.

A plain plate, straight pin tooth, having a shape, size, and color corresponding with the adjoining tooth, is then selected. Straight pin teeth are stronger than those with cross pins; but the lower pin must be in such situation that it will not be ground out in the fitting. Grind the tooth with fine grit corundum wheels until the cervical portion fits perfectly the outer edge of the plate and has the same contour: the cutting edge should be precisely on a line with its fellow and restore the general curve of the incisors, repairing the break of the arch line.

Fig. 635



Bevel the palatal aspect from about one-eighth of an inch beneath to the cutting edge, and bevel the porcelain beneath the lower pin to expose the head of the post (Fig. 631.) Make a small plaster wall to hold the tooth while fitting the backing stay. Should the tooth be a little blue in color, use 24-carat plate for backing; if a trifle yellow, use platinum plate. (Fig. 632.)

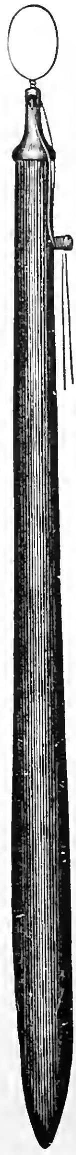
A crown which consists merely of post and plate without collar or band offers no reinforcement to the root to which it is attached, and fracture of a root thus mounted is very liable to occur, particularly in the lateral incisor teeth, in consequence of the leverage thrown upon them during the incision of resistant articles of food (Fig. 635.) Accidents of this nature are not, however, always irremediable, and roots thus broken may often be made quite strong and useful again by forcing a tightly-fitting narrow band of gold around the root at the gingival margin (Fig. 635.)

Usually when such a fracture occurs the artificial crown will soon drop off, and unless the band or collar is applied within a few days of the accident, the fractured parts of the root will be separated by ingrowing gum tissuse, when it will be difficult, if not impossible, to bring them into juxtaposition, but when promptly done the crown may be reset with oxy-phosphate cement with satisfactory results.

COLLAR CROWNS.

The second class of crowns are those in which retention is by means of encircling collars or bands. As the band is the distinctive feature of this class, it will be first described.

Fig. 636



Kirk's dentimeter.

The first requisite of this band is that it shall fit absolutely, not approximately. Faults in this direction are the most common and those to be most guarded against. The second requisite is that these bands shall not be irritating to the vital parts, and yet shall offer a perfect protection against the ingress of pathogenic organisms or their products to the parts we design to protect. This implies that the band shall not impinge on the pericementum, nor must it have any roughened edge or surface to irritate the overlying gum. It should extend to such depth beneath the gum margin that the gingival margin shall form a barrier not the wall of a pocket. The band should grasp, but not irritate; a trifle over one-sixteenth of an inch in depth will be sufficient in the majority of cases.

A method of fitting the collars is as follows: the perimeter of the root is taken by means of annealed brass wire of No. 33 gauge. The ends of the wire are passed through the end openings of a dentimeter, one end being caught fast upon the side pin of the instrument, and by drawing upon the loose end of the nose of the dentimeter, is drawn to within an eighth of an inch of the outer face of the root, when the instrument is turned, twisting the wire and drawing it closely about the neck of the teeth. The opposite edge of the wire loop is held down by means of an instrument to prevent it slipping off the root.

The loop is removed (Fig. 636) and divided at a point opposite the twist, and straightened. The line of greatest disance between the gum line of the root to be crowned and the antagonizing tooth is measured, and a rectangle of plate of that width and the length of the straightened wire is cut.

In the making of a gold band or collar for a tooth or root, it is better to make a lap-joint than an abutted joint, as the lap-joint is stronger and less liable to separate in subsequent solderings. Where no solder is used and the sweating process is employed, the ends of the band may be lapped or simply abutted. This is the strongest union that can be made and the parts cannot be separated by any amount of heat. It is well to have the point of union come on one of the approximal sides of the tooth.

If the operator prefer he may employ a seamless gold collar, procured from the manufacturer, and form this upon a mandrel. Making a soldered cylinder for each case is, however, a

more precise method; moreover, it permits of making the circumference of one edge of the collar greater than that of the other when this difference in the sizes is demanded.

The exact neck forms may be given in the following manner: lay the wire loop as it comes from the tooth upon a smooth flat lead surface, and place over it an old tool-handle, sawed square and given a smooth surface. Strike the wood a hard blow, driving the wire into the lead and wood, leaving both lead and wood marked by the outline form of the wire. The wire is straightened, the gold measured, and the cylinder made as described. It is then bent to fit the indentation made by the wire in the wood, and next further adapted to the groove in the lead. It is then transferred to the root in the mouth, the outline of the gum margin marked on its surface, and the collar trimmed to this line.

It is set upon the root until one portion of it touches the gum, when the outline to which the edge of the collar must be cut is noted, so that it shall be at a uniform depth below the gum line. The collar is cut to this line, transferred to the root or tooth, and pushed into position.

Subsequent manipulations depend upon the class of tooth to be replaced, for there are many modifications of the subsequent operations depending upon whether the tooth has or has not a vital pulp, and whether the root is that of an incisor, canine, bicuspid or molar.

As the molar is the commonest of full gold or barrel crowns, it will be described first. Many time-saving methods are recommended and applied in the making of these crowns, but in most of them time-saving is at the expense of æsthetic results.

FULL GOLD CROWNS.

In the consideration of full gold crowns, as the built up, solid-cusp crown is unquestionably better than any other and as it is probably most quickly and easily made, its construction will be described. The measurement of the root is taken; the band is made of No. 30 coin gold and fitted to the stump, following the gum line carefully and extending about one-sixteenth of an inch below it. It is then cut down a little short of the occlusion, replaced on the stump and the impression and bite taken. The impression should always be taken in plaster of a very fine grade. Modelling composition or wax should never be used. If there are dovetailed spaces or under-cuts to be secured, modelling composition will not give an accurate impression, but whatever the position or condition of the teeth may be, a cast made from a carefully taken plaster impression will be an exact reproduction of the parts.

The bite should also be taken in plaster, and this may be done simultaneously with the taking of the impression. The advantage of taking the bite and impression at the same time in plaster is the absolute accuracy of the relation of the upper and lower teeth which is thus secured. Where the bite is taken in this way, it is possible to make and

articulate a crown or a bridge so perfectly that when it comes from the cast, it is finished and will not have to be touched to correct the articulation when it is placed in the mouth. When a tray is used for the plaster impression and the bite is separately taken in wax, the occlusion of the piece will invariably have to be readjusted when it is placed in the mouth. It is then sent back to the laboratory for a second finishing and polishing, or if it is finished in the mouth, the polishing can never be properly done. The cusps and fissures, which are necessary for perfect mastication, are partly or wholly obliterated and the usefulness and beauty of the piece is destroyed or at least impaired.

As the impression and bite are conjointly taken in a similar manner for a single crown or for a bridge, the description of one will answer for both. Suppose it to be a bridge case; the abutment caps having been made, they are placed in position on the teeth or roots and the patient instructed in opening and closing the mouth so that the correct occlusion may be secured. Every one knows how difficult and at times almost impossible it is to get patients to close the mouth properly. The mandible is protruded or thrown to one side or the other as they bite into the plaster or wax. If while the mouth is open, the patient is told to place the tip of the tongue far back on the soft palate, and to keep it there while the mouth is being closed, it will be difficult for the patient to give the wrong bite, as when the jaw is thrust forward or to one side, the tongue must move with it. In any but large cases, a little salt or potassium sulphate should be used to hasten the setting of the plaster, but in very large cases, nothing should be used for this purpose, as the plaster is likely to set before it can be properly distributed. The plaster should be thoroughly mixed, and when it is so stiff that it will not fall from the spatula when the latter is inverted or turned edgewise, it is ready for the mouth. It is carried in on the spatula and the abutment teeth should be well covered; a few of the adjoining teeth are included in the impression and the plaster is built up thickly in the space intervening between the abutments. The surfaces of the occluding teeth in the opposite jaw are also covered, and the patient is instructed to close the mouth, to bring the teeth tightly together, and cautioned not to move the jaws until the plaster is well set. The teeth which are not included in the impression are carefully examined to see that the jaws are in their correct occlusal relation. With a wet spatula, the plaster may be smoothed and pressed around the teeth and gums on the labial and buccal sides.

The patient is requested to separate the jaws slowly and carefully when the impression is hardened, and it is removed, coming away generally in a more or less broken condition; the broken parts are easily united and fastened together with adhesive wax. The abutment caps are then removed, if they have not come away with the plaster, and placed in position in the impression. Their inner surfaces are to be given a coating of melted pink wax, enough being used to obliterate any under cuts. The impression is then varnished and the cast run.

In extensive cases it is best to use an anatomical articulator, but for most small bridges and for single crowns a plaster articulator may be used. In making the cast from a bite of this kind, the lower half of the impression is run first. The reason for this is, that by having a regular system for running casts, the operator always knows just how to separate them safely. When the sides of the casts are trimmed, the grooves in their posterior extensions (to be referred to presently), will enable him to distinguish at once the upper from the lower side and to know just how to cut without danger of injuring the cast. The casts should be well trimmed and should be no larger than is necessary.

Working casts should always be made of the hardest plaster obtainable. Hard plaster is always coarse and can be distinguished by rubbing a small amount of it between the thumb and finger. It is always slow setting and nothing should be used to hasten this, as rapidity of setting is gained at the expense of hardness. It should be mixed with cold water, and if stirred at all, only just enough to secure a homogenous mass. Much stirring has the same effect as the use of salt or warm water, making the plaster set more quickly but reducing its hardness.

For a separating medium, sandarac varnish gives as good results as any thing that may be used. It is first colored with a little carmine, or a little of the crayon of an indelible or of a copying pencil scraped into the varnish. Only a little of the crayon is needed to impart a pinkish or purplish tint. The impression should be slighly moist for varnishing, since if it is dry, the sandarac will soak into the plaster and will not give a glazed surface; while if it is too wet, the varnish will not adhere sufficiently but will scale off. If the impression has dried out, it should be dipped in water and then laid on blotting or bibulous paper for a few minutes before varnishing. It will make the separation from the cast easier if the surface of the impression is dusted with talcum powder, the excess of which should be blown out with a chip blower. Oil should not be used as a separator, as it has a tendency to make the cast soft. A soap solution makes an excellent separating medium. The impression is coated thoroughly with the solution, using a soft brush to apply it, after which it is well rinsed in clear water. If this is not done and any of the suds are left in the impression, the surface of the cast will be covered with holes and bubbles.

The plaster for the cast should be mixed a little stiffer than for taking impressions. The half of the impression which is to be poured first, is filled with water, the most of which is shaken out, leaving a little in the bottom. A very small quantity of plaster is now placed on the edge of the impression and worked down into it with a jolting or jarring motion, adding a little at a time until it is filled. A small camel's hair brush may be used to work the plaster in, but will give no better results than the method described, if due care is used to avoid the confining of air.

After the impression has been filled, the remaining plaster is scraped

from the bowl upon a glass slab and the filled impression inverted upon this. The plaster should extend an inch or more beyond the distal side or end of the impression and a separating plate (Fig. 637)

Fig. 637

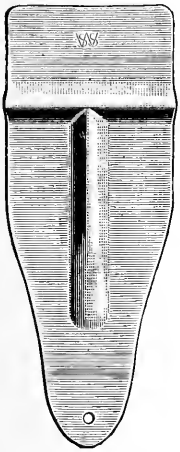
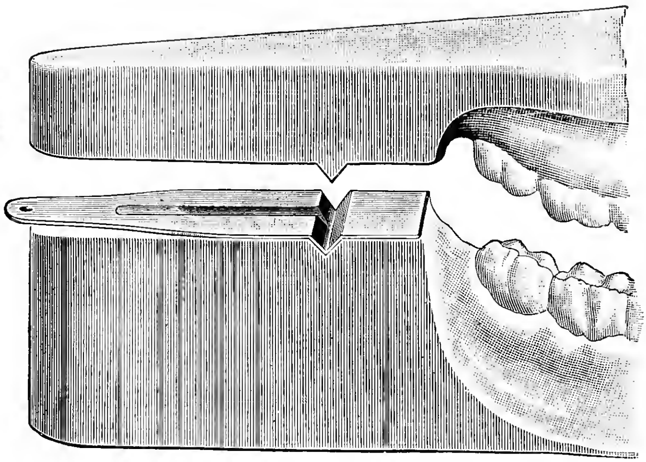


Fig. 638



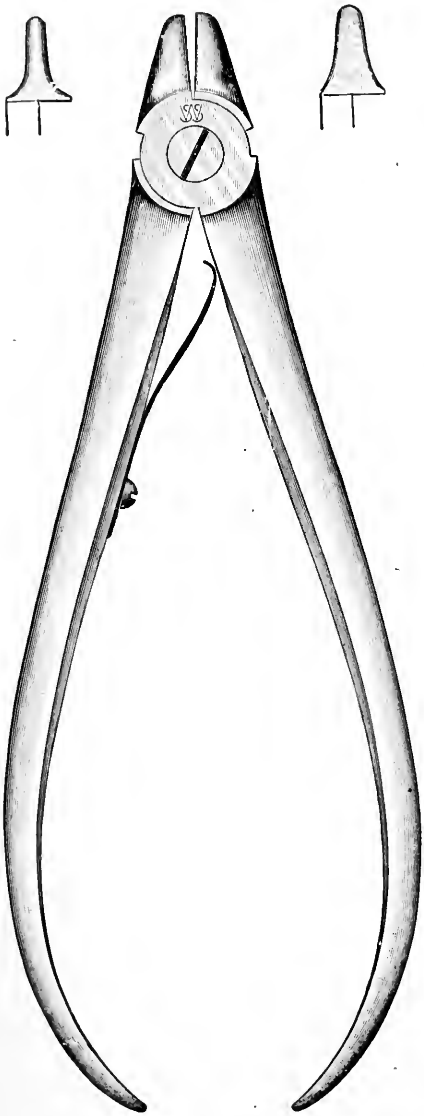
pressed into it, the ridge side down. (Fig. 638.) This is allowed to remain for a few minutes until the plaster has set, when it is removed. The cast is trimmed and the surface produced by contact with the separating plate is varnished, and after allowing it to dry for a few minutes, the upper half is run in the same manner as the lower, covering the varnished extension with plaster and pouring the surplus on the slab, the upper half being pressed into it. After allowing it to harden for a few minutes, it is removed from the slab and trimmed. In the absence of the separating plates, the plaster may be smoothed with a spatula, and after it has become hard, grooves or notches may be cut in it with a knife, after which it is varnished as before. In separating, the impression is carefully cut away from the sides, until the purplish tint from the varnish shows that the cast is near, and the teeth are uncovered as far as possible. When the impression is nearly all cut away, the point of a knife is introduced between the articulating surfaces and by a little careful prying, the halves are separated, after which the remainder of the impression is easily removed. The casts are then trimmed and smoothed and if they are rubbed with talcum powder, it will give them a beautiful polished surface.

Fig. 639

If the tooth or root has been properly prepared, the band may be made and the crown or bridge completed without the band having been first fitted in the mouth, the whole of the work being done on the pre-

pared cast. In preparing the cast for this procedure, it is first dried thoroughly and then trimmed, cutting down on a line with the sides of the tooth to nearly one-sixteenth of an inch below and parallel to the cervical margin. (Fig. 639.) After the trimming, it is soaked with thin sandarac varnish and again dried. This will make the cast hard enough to withstand the wear incident to fitting the bands. The sandarac varnish as purchased at the dental depots, diluted one-half with alcohol, is suitable for this purpose.

Fig. 640



If the band has been fitted to the tooth, and after the articulating cast has been obtained, it is removed by grasping it with a pair of slightly heated pliers, which melts the wax at its inner surface: the wax is burned off and it is cleansed in dilute sulphuric acid. The contour is made by stretching the band toward the occlusal portion. This may be done on the beak-iron of an anvil with a small hammer, or with a pair of stretching pliers designed especially for this purpose. (Fig. 640.) It is then annealed and given the desired shape with the fingers and collar pliers. The band is placed on the cast and the buccal and lingual sides grasped between the thumb and finger and pressed in until they are on a line with the other teeth. The pliers are then used to make the buccal and palatal or lingual fissures and to remove any little irregularities which may exist in the band. It is now cut short enough to allow the placing of a thick solid cusp and the top edge filed perfectly flat. If from a plate or buttons a suitable cusp can be selected, a matrix of very thin pure gold is made from it by swaging into a Melotte's metal die, and this is filled with coin gold and the under surface filed flat so that there will be perfect contact between its periphery and the

band. These are then wired together with iron binding wire, the wire being twisted at the under side of the band as in Fig. 641, and a little borax or soldering fluid placed around the inside at the point of contact with the cusp. A couple of pieces of solder are now placed on the inside next to the band and the crown held over the flame of a Bunsen burner by the twisted wire until the solder has flowed all around. The wire is then removed, the crown cleansed in acid, any overhanging edges of the cusp ground away, and the crown finished and polished.

In the event of a suitable cusp not being found, the top of the band may be filled with soft plaster or modelling composition and the occluding teeth, having been previously covered with oil or talcum powder, pressed into it. After the plaster or composition has hardened, the cusp is carved to represent as far as possible a typical cusp for the given tooth, and a die of fusible metal made and solid cusp secured as already described.

Fig. 641

A much better way of making these crowns, is to use no solder at all, but to sweat the joints throughout. If solder is used, it is sure to discolor in time and dark lines will indicate the several joints. The sweating of the band is best done with the blowpipe. The band is placed on a charcoal block with the seam to be united uppermost, covered with a little borax or soldering fluid. The flame used is the inner blue point of the blowpipe-flame and should be from an inch to an inch and a quarter in length. The whole of the band is brought to a very bright red heat and the point of the blue flame gently passed over the joint, melting the gold together at that point and at no other. This makes a stronger union than can be made with any solder. The higher the carat of the solder used, the stronger is the union and where none is used, the band will be practically seamless and as strong, or stronger at that point than at any other. The band is then festooned, contoured, and filed flat as already described. The cusp is made and wired to the band as in the soldered crown. It is then fluxed and held by the twisted wire with a pair of light pliers, cusp down over a Bunsen flame well toward the top, so that the thick cusp will be heated first until it is nearly at the melting point. The crown is then lowered a little in the flame and held until the gold begins to melt and unite the band with the cusp after which it is cleansed in acid and the crown finished and polished.

JACKET CROWNS.

There are times when it is desirable to preserve the pulp of a tooth anterior to the molars where through accident or decay the tooth is too far broken down to be restored with inlays or fillings. As in the six or eight anterior teeth the placing of a gold crown is out of the question, it becomes necessary to make a shell which will cover the stump and protect the pulp, to which may be attached a porcelain facing. The

face of the tooth is ground away as much as possible without endangering the life of the pulp, cutting well under the gum as in Fig. 642. The sides and palatal portions of the tooth have their enamel removed, so that the band will hug the root tightly under the gum. (Fig. 643.) The band is then made and fitted to the stump and cut out on the labial side flush with the tooth. (Fig. 644.) The palatal side of the band is then pressed in close to the stump and the mesial and distal sides of the band spread out nearly or quite to the width of the facing which is to be used, and a floor of coin gold sweated or soldered to it. (Fig. 645.) A thin facing is then ground so as to leave a little space between it and

Fig. 642

Fig. 643

Fig. 644

the cap, touching the latter only at the tip. (Fig. 646.) The facing is now backed with thin platinum or crown metal, letting it extend about one-sixteenth of an inch over the incisal edge. It is then waxed to the cap, invested and soldered, flowing the solder between the facing and the cap and if necessary over the palatal portion of the band. (Fig. 647.)

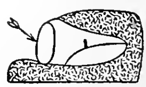
Another way of making this crown is to carry the band to the full height of the tooth, to contour it, and cut it out on the face to the depth of the facing. The facing is then ground to fit the edge of the cap so formed and a backing of coin gold fitted carefully to it. This is then adjusted to the cap, waxed, the facing removed and the backing soldered to the cap with 22 carat solder. The facing is then put in place,

Fig. 645

Fig. 646

Fig. 647

Fig. 648



the pins waxed on the inside of the cap, and the crown invested. The crown is invested face down and covered but lightly, leaving the opening fully exposed as in Fig. 648. It is thoroughly dried out and flux placed on and around the pins. A piece of 18 or 20 carat solder is then placed over the pins, the whole brought to a bright-red heat, and with the fine blue point of the blowpipe-flame thrown on the inside the solder is melted, uniting the facing to the cap.

In the making of a porcelain faced crown for a bicuspid having a vital pulp, the tooth is prepared in the same way as in the anterior teeth, cutting it well out on the buccal side and grinding away the inner cusp. (Fig. 649.) The band is then made as for a full gold crown, and cut even with the cusp at the top and enough on the buccal side to

allow for the facing. (Fig. 650.) The facing is then ground to fit the edges of the cap (Fig. 651) and a backing of coin gold fitted to it. (Fig. 652.) The backing being fitted to the facing, it is placed in position on the cap and waxed and soldered with 22 carat solder. The backing is then cut off even with the rest of the band and filed flat. (Fig. 653.) The tip of the facing is then ground on a bevel with an angle of about forty-five degrees, the lower edge of the bevel being on a line with the top of the cap. (Fig. 654.) A cusp is then selected, the under surface filed flat and the buccal side beveled to meet the bevel of the facing. (Fig. 655.) The cusp is then wired to the cap and soldered with 22 carat solder, the facing having first been removed. The cap is then

Fig. 649

Fig. 650

Fig. 651

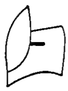
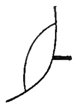


Fig. 652



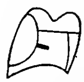
cleansed in acid and the facing replaced in position and waxed. It is then invested and soldered from the inside as already described. (Fig. 648.)

Another method of attaching porcelain facings to the gold barrel crown is by first making the entire crown of gold, the barrel and articulating surface being completed. The external wall of the crown has the segment made visible by the movements of the lips sawed out, and the cut edges of the metal beveled. A porcelain facing is selected of a size to fit the space with the minimum grinding. It is to be ground in until all of its edges fit those of the barrel. A stay of No. 34 pure gold is burnished over the back of the porcelain tooth. The edge of

Fig. 653

Fig. 654

Fig. 655



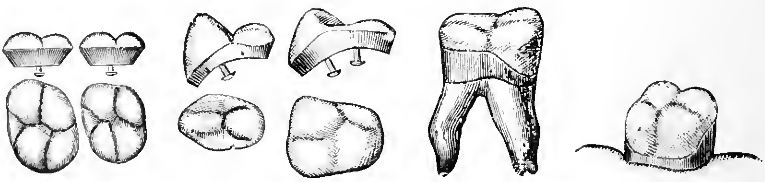
the stay should be accurately adapted to the barrel. The crown and facing are cemented together with adhesive wax, covered by a thin investment, and soldered by means of a blowpipe-flame directed against the portion of the investment covering the facing.

The buccal and articulating faces of molars and bicuspids may be made of porcelain, the attachment of the crown to the root being secured by means of a gold barrel. The barrel is made as for an all-gold crown. A wax-bite and impression are taken, and an articulation mounted. Before cutting away the buccal wall of the barrel for the reception of the porcelain, measure by means of a wire and dentimeter the circumference of the upper portion of the barrel. The loop made is taken to the depot, and a saddle-back or a plain rubber tooth is

selected, the circumference of which agrees with that of the barrel (the wire loop). The tooth should have but little thickness of porcelain above the pins (Fig. 656); the S. S. W. cusp crowns are designed for this special use. A scratch is made along the buccal portion of the barrel, marking it slightly above the gum line and between the adjoining natural teeth along the line of exposure. A fine saw is used to cut away the buccal walls to these lines. The palatal wall of the barrel is cut down if necessary to admit the face, so that it will articulate with the antagonizing teeth. Should there be any lack of correspondence between the outlines of the barrel top and the cusp crown or tooth, the gold is bent to fit the latter accurately. By means of fine-grit corundum wheels the edges of the porcelain are closely adapted to the cut edges of the gold at the cervical and approximal borders, and articulated perfectly with the antagonizing teeth. The tooth and barrel may now be set with cement: it is preferable, however, to solder the porcelain to the barrel. A piece of 24-carat gold No. 33 is fitted as a stay to the under surface of the porcelain and burnished into accurate contact. The tooth and stay are set in the barrel, and the latter is cut away at points interfering with its correct placement. It is boiled in the acid solution, and invested so that the interior of the barrel and the stay exposed form a concavity. Borax is painted around the line of junction and

Fig. 656

Fig. 657



Cusp crowns.

over the pins, a small piece of solder placed over each pin, and three or four pieces around the joint, and the piece is gradually raised to a high heat; a fine flame directed into the concavity fuses the solder, uniting the pieces perfectly.

In finishing the crown the gold should be dressed down to the porcelain, making a perfectly smooth joint. No projection of the gold beyond the surface of the porcelain should remain.

Fused porcelain may be used in lieu of solder to attach the crown to the barrel, as described by Dr. Robert Huey: "The barrel is fitted and cut out as described. One of Ash & Sons' diatoric teeth is selected and fitted to the barrel. Openings are drilled through the mesial and distal walls of the barrel, which shall exactly uncover the openings of the tube in the tooth. A piece of platinum wire is thrust through holes and tube, holding the porcelain to the gold. The platinum wire is now

either riveted or soldered to the barrel. The line of junction between gold and porcelain is painted with a paste of dental glass, which is then fused in a Downie furnace."

Dr. W. A. Capon claims excellent results for a platinum and porcelain jacket crown, the details of the construction of which are as follows:

"This crown is made by fitting a platinum band (gauge No. 31) to the root of prepared tooth (Fig. 658) in the same way as with gold cap work, except that the joint must have overlapping instead of abutting edges. The lingual and labial outlines of the adjacent teeth are marked on the tube (Fig. 659), as a guide to grinding those portions away to gain shape instead of cutting with scissors. The lingual side is shaped with a wheel on the lathe and a piece of the same gauge platinum soldered to fit it with very small amount of pure gold. (Fig. 660 and 661.) After

Fig. 658

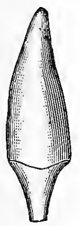


Fig. 659

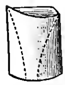


Fig. 660

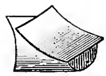


Fig. 661

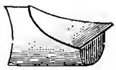


Fig. 662

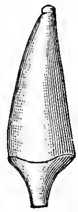
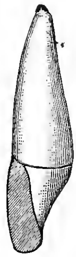


Fig. 663



trimming and fitting to the root, the labial surface is ground thin enough to burnish and fit over the tooth (Fig. 662), after which a thin porcelain veneer is fitted and held in position by the porcelain paste. It is carefully dried and baked in the same way as other porcelain crowns. The crown is now fitted to the root and its requirements noted, such as proper size, shape and thickness. If the surface of the veneer requires grinding, it should be done at this stage, so that it will be glazed again by the last heat, which should be strong and of uniform degree. After final baking the platinum portion is polished and the crown is ready for setting, using thin cement and very gentle pressure (Fig. 663.) The crown should fit easily, as there is danger of breaking the thin porcelain on the sides of the crown, or of even checking the veneer itself.

The joints are lapped and made as close as possible, so that great and frequent heating will not entirely destroy the union; any excess of solder will flow over the surface of the platinum, and destroy the porcelain adhesion, which may not be noticed at the time of the operation, but will be more forcibly noted later on. The lingual surface is ground thin to give shape, so that there may be two flat surfaces to hold porcelain. When finished it gives the proper tooth contour."

BAND AND PIN CROWNS.

While a pin and plate crown or any of the manufactured crowns are especially adapted for temporary work, where permanent operations are desired, the root should always be banded so as to reduce to a minimum the possibility of a fracture. It is always best to be on the safe side in the beginning and to treat a root so that there is no possibility, or at least a very remote one, of trouble of this kind. Of all the crowns placed in the anterior part of the mouth in which the roots are banded, the Richmond crown is the one which is most frequently used and is made as follows:

The root having been properly prepared as already described and the band fitted to it, the latter is marked around its inside and cut off flush with the top of the stump, which should be about one thirty-second of an inch under the gum on the labial side and about one-sixteenth of an

Fig. 664

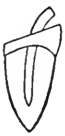
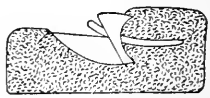


Fig. 665

Fig. 666

Fig. 667



inch above it on the palatal. A floor of No. 30 coin gold is then sweated or soldered to the band. It is now replaced on the root and a hole made in the floor over the enlarged root-canal for the reception of the pin, which latter is preferably made of platinized gold. This is placed in position and fastened with adhesive wax (Fig. 664), removed, invested and soldered. It is then put back on the root and the impression and articulation taken, after which the cast is prepared in a manner already described. After separating, the cap is removed from the cast with a pair of heated pliers and the floor on the labial side of the pin is ground or filed perfectly flat. It is then replaced on the cast, and a suitable facing selected and ground to fit the floor of the cap. (Fig. 665.) A backing of thin platinum or crown metal is then made, extending from the floor of the cap to about one sixteenth of an inch above the tip (Fig. 666.) The facing is then waxed in place with adhesive wax, and when this is nearly hard, it is pressed tightly against the backing to bring them into close contact. The crown is now removed from the cast, invested and soldered. The investment should be made to cover the band partly and take in the backing which extends beyond the cutting edge, thus holding it down and preventing it from drawing away from the facing in soldering. (Fig. 667.)

A favorite and easy way of setting in the facing, is to grind it away so that only the tip of it touches the floor of the cap at its outer edge, and then to let the backing extend all the way to the end of the facing, and

fill it in with solder. (Fig. 668.) The principal objection to this method, is that in many cases the gold can be seen from the front or side of the mouth, or there is a dark shadow between the teeth toward the gingival portion of the crown, which renders it unsightly and unnatural in appearance.

In the making of the so-called Downie porcelain crown, where a facing is used, the band and cap are made in the same way as for a Richmond, with the exception that iridio-platinum plate No. 32 gauge,

Fig. 668

Fig. 669

is used instead of gold and the band is cut lower on the palatal side. For these crowns it is well to have only the tip of the facings touch the outer edge of the cap, as this permits the porcelain body to be worked under the facing better than when it is close to the floor. (Fig. 669.)

The Half-cap Crown.—While the full Richmond crown in point of strength and impermeability, may justly be considered as the ideal crown, the one serious objection to it is the difficulty of concealing the labial portion of the collar. No method of crown construction can be

Fig. 670

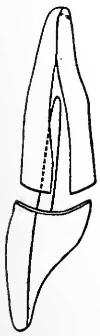
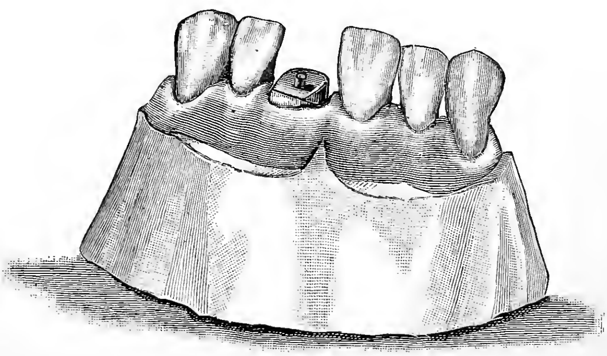


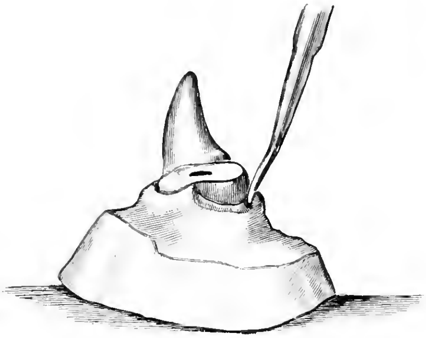
Fig. 671



said to be perfect which allows any of the metallic portion to be visible after it is permanently fixed. For this reason a large number of crowns which are set on upper anterior roots are constructed on the half-cap plan. When the half-cap is accurately fitted at the lingual aspect, it is nearly as strong as would be a full cap or collar. An additional advantage will also be found in the fact that the use of the half-cap obviates the necessity of forcing the collar under the gingival margin at the labial portion to such an extent, in order to get it out of sight, that periosteal disturbances may result. As shown by Fig. 670, in the absence of

lingual reinforcement, the post becomes a lever, and its force is exerted from the centre of the root and falls upon its labial or buccal half, resulting eventually in splitting of the root. The half-cap, as shown by Fig. 671, places the reinforcement where it is most needed, while it

Fig. 672



admits of so nice an adjustment of the porcelain facing that its neck may be made to pass far enough under the gum-margin to simulate closely the appearance of the adjoining natural teeth. Much of the

Fig. 673

preliminary work in the construction of such a crown may be done on a good plaster cast. The root should first be prepared, including the enlargement of the canal for the reception of the post; the latter is then placed in position and a plaster impression obtained. The plaster

cast requires no modification, except that the plaster should be cut away at the gum-margin of the lingual aspect, as shown by Figs. 672 and 673, to enable the operator to carry the half-collar slightly under the gum (Fig. 674.) The half-collar should be accurately fitted to the convexity of the remaining portion of the crown and as much of the root as it embraces; the floor of the cap is then made and soldered to the pin. The collar portion of the cap is then to be tacked to the floor by a minute particle of solder, as shown by Fig. 675; the cap should then be tried upon the root to ascertain whether the adjustment is perfect, and to improve it, if necessary, by pressing the edge of the collar to complete contact with the root at the gingival margin with a burnisher. After which

Fig. 674

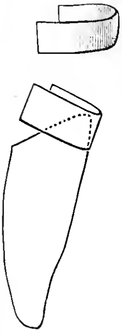


Fig. 675

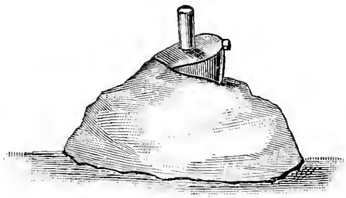
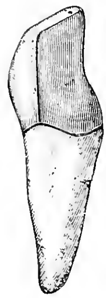


Fig. 676



the collar and flat piece with the post are united by the smallest amount of solder practicable. The selecting and fitting of the porcelain tooth to the cap and the subsequent soldering and finishing are the same as in the full Richmond crown. Fig. 676 shows the completed crown.

READY-MADE CROWNS.

Of the ready-made porcelain crowns there are two varieties—first, those designed for fixation upon a post which is previously fastened in the root; second, those having a pin baked in them. To the first class belong the Bonwill, the Davis, the S. S. White detachable pin crown, the Fellowship and various others on the market: in the second class are included the Logan, the Brewster and several others. Crowns which are formed and adapted by means of sets of ready-made appliances, such as the Hollingsworth and the mandrel systems, belong to the class of built-up crowns.

Of the ready made porcelain crowns, the Davis, and S. S. White detachable post crown are those having the widest range of usefulness. The methods of fitting and mounting them are similar, and as a description of the technique of these operations would apply equally well to all, the following is quoted from Dr. G. W. Schwartz concerning the use of the Davis crown.

Rapid Method of Setting Davis Crown.—"We shall first consider the easiest and most rapid method of setting the Davis crown, which is as follows: having the root properly prepared to crown, grind it even with the gum line and enlarge the canal to receive the post. Next, cement it in place in the root. Now select a suitable crown and cement it to the post as shown in Figs. 677 and 678. If you prefer, you may cement the post in the crown first and then the crown and post may be cemented to the root, or, you may cement the crown to the post and the

Fig. 677

Fig. 678

Fig. 679

post in root at the same time if you choose, with results shown in Fig. 678.

If you wish to follow a more conservative method of setting this crown without banding the root, I would suggest that the root be ground at a bevel from the lingual margin to the centre of the root, as shown in Fig. 679. This preparation of the root, by reason of the bevel from the lingual margin to the centre of the root, prevents liability to displace-

Fig. 680

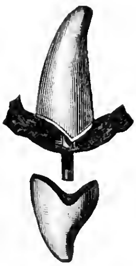


Fig. 681

Fig. 682

Fig. 683

ment from stress of mastication or incising force; also any possibility of splitting the root from the same cause. The concavity from the labial margin of root to the centre gives plenty of room for thickness of porcelain, thus insuring its color.

The next step is to cement the post in place to the root and select your crown. After the cement has set sufficiently not to disturb the post, you can begin grinding your porcelain in place. This may be done as follows: first, grind it to fit as nearly as possible, then insert a thin piece of carbon paper around the post so that it will come between

the root and porcelain, as shown in Fig. 680; by using a little rotary pressure, the carbon will leave little marks on the porcelain wherever it touches it. Grind until the surface is evenly marked by the carbon. With a little care a very close adaptation can be had by this method. When the porcelain is properly ground, dry the post and root and cement in place, which completes this operation, as shown in Fig. 681.

Gold Banded Root.—Grind the root evenly to the gum margin, removing all enamel from it, thus giving the labial portion of the root a slight bevel. This bevel is for the purpose of covering the band by closely grinding the porcelain crown to it, as shown in Figs. 682 and 683.

Having the root prepared and the canal enlarged, take a measurement of the root, cutting the band snug that it may take the beveled shape when fitted on. After the band has been properly fitted, solder the cap, then fit the post in and solder them together as in Fig. 682. Now replace the cap on the root and you are ready to grind in the porcelain. Another way is to take an impression at this point and run a model with the cap in place, using the model to work with rather than

Fig. 684

Fig. 685

the patient. In this case grinding in the porcelain gives the dentist a chance of showing his skill. It is a clever piece of work, requiring some patience when neatly ground in, but one which repays in satisfactory results. I use small corundum stones of different grits to do my first grinding. The fine grinding is done with a rubber corundum point mounted with jeweler's cement in a smooth porte polisher. After the porcelain is correctly ground, cement the crown to its place on the cap allowing it to set out of the mouth. Finally cement it to the root in the usual manner or set it with gutta-percha. Fig. 683 shows this crown finished.

In Porcelain.—Platinum Matrix Without Band.—Prepare root as shown in Fig. 689. Take a piece of soft platinum plate, 36 gauge or less, and burnish this over the root until its margins are distinctly outlined. (Fig. 684.) Punch a hole in this matrix where the post should go, using a plate punch. Take an iridio-platinum post and push it into place in the root-canal through the hole made in the matrix. Now remove the matrix and post together, and solder. Pure gold will do to solder in this case. Replace matrix on root and burnish to place again. By trimming off all excess platinum, you will have a matrix following the marginal outline of the root. (Fig. 685.) You are now ready to select the porcelain crown to be baked to this post and matrix. Grind the porcelain to fit matrix as shown in Fig. 686. Put some thin body in the post hole

of the crown, being careful to work it to place on the pin. Let it dry. Then put the crown on a crown tray with two small rolls of asbestos under the matrix as shown in Fig. 687. These rolls, one on each side of the post, prevent the matrix from coming in contact with the tray and to obviate the danger of its changing shape or fusing to the tray. You are now ready to put it through its first baking. This should not be carried beyond a good biscuit. After the first bake, try it in the mouth to see that it is correct. If the porcelain needs grinding to conform to the outline of the matrix, as it usually does, do so before the second baking and polish the ground surfaces with disks; remove all foreign substances from the case by careful cleansing and after filling the spaces beneath the matrix with porcelain body, bake.

If the work has been thoroughly done, this should complete it and it should come out of the furnace a beautiful piece of work. As the ma-

FIG. 686.

FIG. 687.

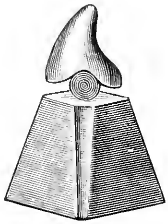


FIG. 688.

trix has now served its purpose it should be removed. If it were left on the crown, it would have a tendency to produce a blue shade at the neck which is to be avoided. To remove the matrix, take a small, round bur and drill through it close to and around the post. Next, take a sharp pointed excavator and, beginning at the lingual margin, continue to raise the matrix up until the entire matrix comes away from the crown. This crown should resemble Fig. 688 when cemented in place.

Platinum Band, Iridio-Platinum Post. Prepare the root for this crown in the manner illustrated in Fig. 682. The metal work is done by the same method but with the following difference in materials: platinum is used instead of gold for the cap and band and an iridio-platinum post is substituted in this case for the Davis post used in the other. The reason for this substitution of platinum is obvious. This crown is to be put through the furnace. Having proceeded to the point of having the platinum cap and post in place on the root, take the bite and a plaster impression, melt a small quantity of wax in the platinum cap and run the casts. This placing of wax in the cap facilitates the removal of the latter from the cast. Before going farther it is well to see that the wax is out of the cap and that the cap goes on and comes off the cast easily. After placing the cap again on the cast you may proceed to grind in the crown.

For the purpose of getting porcelain body in for the last baking, two V-shaped spaces should be ground in the crown, one mesially and one distally; Fig. 689. When properly ground and ready for the first bake, the crown should touch the cap at a labial and at a lingual point.

To fasten the crown and cap together for the first bake, put some thin body in the post hole of the crown, carefully letting it settle to place on the post and cap. After allowing this to dry, gently remove it from the cast, place it on a crown tray for the purpose and biscuit it in the furnace.

When it has gone through the furnace for the first time, try it in the mouth and then do the necessary grinding and polishing. Before baking for the last time it should be thoroughly cleansed and the porcelain body packed into the case in such a manner as to give it the proper contour.

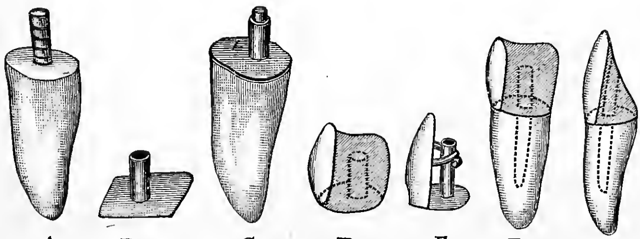
Fig. 689

There are two strong points in favor of these crowns which it might be well to mention. The first is, there is no soldering to be done where there is danger of checking porcelain. The second is, they are easily repaired when broken in the mouth.

Lastly, when a patient comes to you with a Logan post fast in the root, grind in a Davis crown and cement it in place."

The system of porcelain and jacket crowns of Dr. C. H. Land of Detroit, Mich., is similar to the above, only in that the pin is first permanently fastened into the root; in other respects it admits of more precise adjustment and is more durable. The principle involved in the construction of a Land crown differs from all ordinary methods in the following particulars: "The post, or screw, is firmly fixed in the root by cement or amalgam (*A*), then a tube with flange (*B*) is put

Fig. 690



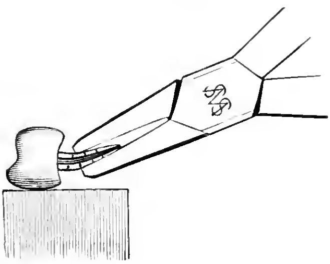
on the post and the flange burnished or malleted to conform to the surface of the root, and trimmed to its exact contour (*C*). A pinless veneer (*D*) is then baked on this 'matrix' or tube. This makes a tube tooth in fact which is cemented on the post and root. Flat back teeth or facings may be used instead of the pinless veneers and the pins soldered to the tube (*E*). *F* and *G* show finished crowns. In case of breakage, the porcelain crown can be removed, leaving the post in the root, a new facing can be baked on and contoured and cemented on the root as be-

fore. This avoids the necessity of removing the post from the root." The Custer or Downie furnace may be used in fusing the porcelain in the construction of these crowns.

The next class of crowns is composed of those having their platinum posts baked in them: they are the Logan, the Brewster and several others of this type.

The first of these has the widest range of application, and is the form in most general use. Being composed of porcelain alone, and having no underlying mass and backing of metal, they present a translucent appearance not to be had with those forms of crown which are built up in part of metal. An excellent method of selecting and adapting these crowns is as follows: the root face is trimmed by means of rotatory files or the Ottolengui root-facers, to the level of the gum margin. The canal is sterilized, and the upper third hermetically sealed, the remainder of the canal enlarged to about one-sixteenth of an inch in diameter. A wax-bite is taken, including several of the adjoining teeth. A piece of iron wire one-half of an inch longer than the reamed portion of the canal, and small enough to slip very freely in it, has its end bent into a loop and the canal portion covered with gutta-percha, which is then oiled and slipped in the root A plaster impression is taken in which the coated wire is withdrawn, and a cast made of fusible metal melting at about 150° F. A shade tooth and a crown corresponding with the natural teeth are selected. The direction of the axis of the root-canal is noted, and the angle which it makes with the root face compared with the direction of the axis of the selected crown: not infrequently it is necessary to bend the pin at an angle with the axis of the crown itself (Fig. 691). The opening in the root, made by withdrawing the gutta-percha and wire, is enlarged sufficiently to receive the post of the crown.

Fig 691



The pin is bent, if necessary, so that the axis of the crown is parallel with that of the natural fellow, bringing the cutting edge of the artificial crown in the arch of the natural teeth. The points of contact between the edges of the crown and the face of the root represented in the metallic cast are ground from the porcelain until there is a uniform contact throughout the crown edge. The grinding is done by means of square-edged corundum wheels on a laboratory lathe or by an engine wheel, as shown in Fig. 692. The cutting edge of the artificial crown should exactly repair the break in the arch. Its palatal surface is cut away, if necessary, to articulate with the antagonizing teeth, in which event the cut surface should be smoothed and polished. The canal is enlarged by means of fissure burs or Ottolengui's reamers (Fig. 693) until the pin slips readily into place and the surfaces of crown and root are in contact. Should either the edge of the crown or the edge of the

root project beyond the common line at any point, it is to be trimmed down until the line of junction is uniform. Any slight imperfections of contact are to be remedied by means of the carbon-paper test: small pieces of this mateial, large enough to cover the face of the root, are pressed to its surface and perforated by the crown post. The crown

Fig. 692

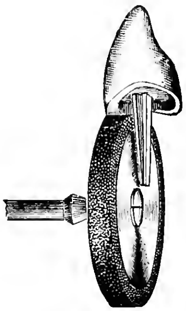
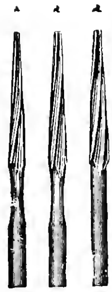


Fig. 693



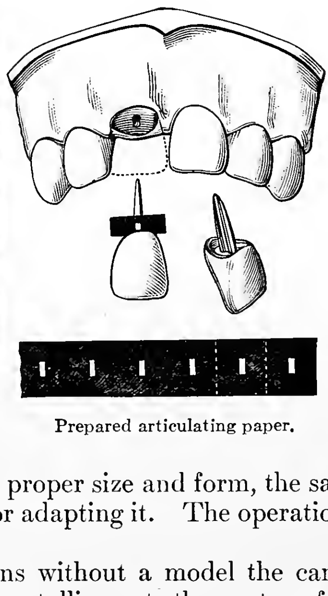
is now pressed firmly into position and withdrawn: should there be any breaks in the black line, the crown is dressed down at all parts marked until there is a continuous black line at the outer edge of the crown.

The crowns may be accurately adapted to the roots without the use of a model, but as it is desirable to make a model to serve as a guide in

Fig. 694

Punch for making holes in articulating paper.

Fig. 695



Prepared articulating paper.

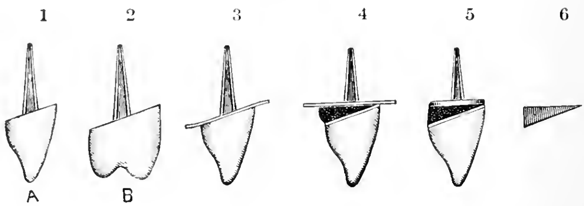
selecting a crown of the proper size and form, the same model may furnish a base and guide for adapting it. The operation described in reality saves time.

In fitting these crowns without a model the canal is enlarged sufficiently to receive the metallic post, the root surface trimmed to the

proper form by means of the root-facers, and the crown is fitted as follows:

Dr. E. C. Kirk's Method of Fitting a Logan Crown to a Tooth-root.[1] —Cut several small pieces, about one-quarter inch square, from a strip of thin articulating paper. In the centre of each punch a hole with the tool shown in the margin. Having prepared the root-end, slip the perforated piece of articulating paper over the pin of the Logan crown and press it firmly into position, in contact with the root. Upon withdrawing the crown and removing the articulating paper, the points of contact will be found to be marked black. Grind these off carefully, readjust on the root as before, grind again, and continue the operation of fitting and grinding until the mark made by the articulating paper on the contact surface of the crown presents as a uniformly unbroken black ring. When this has been accomplished, the crown will be found to fit the root-end with the utmost accuracy. The advantages of fitting a crown directly to the root are, it would seem, self-evident from the

Fig. 696



mechanical standpoint, and involve besides the least expenditure of time.[1]

A Method for Perfectly Adjusting the Logan Crown.—"By making a considerable change in the present form of the Logan crown, as shown in Fig. 696, 1, *A* and *B*, we have a crown that can be adjusted in a few minutes, and with a degree of perfectness not yet obtainable by any crown on the market, nor, within my knowledge, by any so far suggested method.

"The manner of making the adjustment is certainly as simple as could be desired.

"After preparing the canal for the reception of the 'Logan pin,' select a tooth in the usual way, having regard to correct length, width, and color, and if care has been exercised to select one as near the right length as possible, it will only be necessary to touch the buccal or labial point of the neck of the crown a few times with the corundum wheel, and the proper length or bite will be obtained. Next take a disk or small piece of thin platinum foil, about No. 50, and push through this the pin of the tooth, carrying the disk up against the porcelain, as represented in Fig. 969, 3. With a little drop of Parr's fluxed wax dropped in the triangular space, formed by the backing and the pin, the disk is held

[1] Dental Cosmos, June, 1894.

securely in place, and the platinum is trimmed around with small scissors, that there may not be any overlapping. Now place around the pin on the platinum a ball of Parr's wax, stick the pin through the second disk of the foil, and rub the platinum with a hot instrument, that the wax, and disk may be sealed together, as shown in Fig. 696, 4. Place this in ice-water to harden the wax, so as to resist pressure. It is now ready to insert, and by pressing the tooth up until the labial surface strikes the end of the root, and having the patient to close the jaws, the correct bite will be secured with the opposite tooth. It will be found on the removal of the crown that the platinum next the root has been perfectly swaged to the root-end. This second disk is now trimmed according to the outlines of the root. When it is so desired, the palatal side of the root having been left a little high, or just above the gum, the platinum can be split with scissors, lapped, and burnished around the exposed side of the root, to form a partial band (Fig. 696, 5).

"After having dried the wax with bibulous paper and shaped up the approximal sides, these sides are covered with small, triangular pieces of platinum (Fig. 696, 6) by lapping the platinum on the wax and rubbing over it a hot burnisher. The crown is now ready to invest, an the investing mixture is poured on a small piece of wire netting, which will prevent its cracking during the soldering operation. The wax having been burned out, this triangular box is filled flush with solder in the usual way and polished. The result is a beautiful and perfect crown, in every respect the most substantial porcelain crown we have.

"I frequently make the crown without using the triangular piece of platinum to form the box (Fig. 696, 5), relying on the investment to form the sides. This saves a little time; but it frequently happens, unless care has been taken to make the wax flush, that the approximal surfaces are not well rounded, and consequently do not finish well. It is, therefore, safer to use the triangular pieces of platinum foil to form the sides of the box, as described, before filling with solder. This plan is particularly adaptable to those cases of fracture which have resulted in a rough root-end, and where it is often next to impossible to get them smooth.

"Where it is convenient or if it is desired, the triangular box can be filled with 'body', and baked in a Parker furnace from six to eight minutes. This gives us an all-porcelain crown which fits perfectly to the end of the root. In this case the first disk next the porcelain is left off entirely." [1]

Caution.—The Logan crown contains a large tapered pin with its large end baked in the tooth, and when heated to flow solder over or around it, care must be taken that the porcelain is made as hot as or hotter than the pin, thus preventing uneven expansion and cracking of the porcelain.

These crowns may be adapted upon frail roots, which demand the supplementary support of a band encircling their necks. It is a

[1] Gordon White, D. D. S., Dental Cosmos, January, 1893.

matter of but little practical moment whether the collar is or is not attached to the crown: the object sought, the protection of the root against longitudinal fracture, is secured by banding the root first, forming an artificial root face by means of metal. The root face is trimmed as for a collar crown; the collar is fitted and a cap soldered to it, the edge of the top being hidden at its labial aspect by the gum. While the cap is on the root an opening is made in it considerably larger than the size of the crown post. A piece of metal longer than, and slightly larger on its sides than, a full Logan post is greased with vaseline; the root is dried, zinc phosphate is packed into it for more than half its length, the ferrule partly filled by the same mixture and pressed into position. While the cement is soft the metal wedge is thrust into the cement as deep as a Logan pin, and left until the cement hardens, when it may be readily withdrawn. The crown is now adjusted to the canal in the cement and to the edges of the ferrule top. The gold of the cap may be dressed away, together with a portion of the cement, until but a narrow retaining rim of gold is left.

Fig. 697

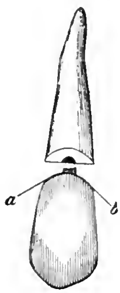


Fig. 698

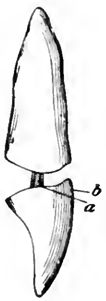
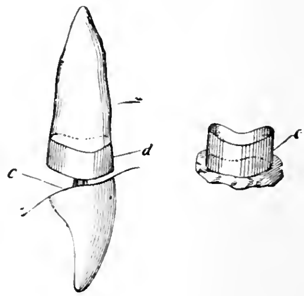


Fig. 699



Logan crowns adapted after this manner are to be cemented into position as follows: an appropriate root clamp (Ottolengui's) is placed on the root, and the rubber dam slipped over several adjoining teeth and the clamp. The root is well dried by means of alcohol and the hot blast; the canal is wiped with a pellet or cone of paper saturated with the cement fluid to facilitate the flow of the cement. A paste of cement is made just thick enough to be formed into perfectly plastic pellets; one of these is rolled into a cone, and before the latter bends by its own weight it is carried into the canal; another is pressed into the concavity in the base of the tooth; the grooves in the post are filled; the crown is then thrust into position and pressed home, when the cement will ooze from the edges, and the joint should be a very thin line. The crown is left undisturbed for at least fifteen minutes, when the cement will be found hard enough to resist fracture.

Dr. Hollingsworth's Method for Accurately Adapting and Mounting a Logan Crown with a Band.—"Prepare the root in the usual way for banding. (See Fig. 697, front view, and Fig. 698, side view.)

"Grind the abutting surface of the crown to fit the root under the free margin of the gum, along the labial face only. (See Figs. 697 and 698, *a* to *b*.)

"Cut the crown away slightly at the lingual surface, so as to leave a space between it and the end of the root. (See Fig. 699, *c*.)

"Make a band only wide enough to give a good ho d on the root, but not to extend beyond margin of gum, to fit the root and trim off even with the end of it. (See Fig. 699, *d*.) After fitting the band properly remove it and solder a piece of pure gold plate, say about No. 34, on the outer end. (See Fig. 699, *e*.) This can be done quickly by placing the plate in the hand and pressing the band on it with the thumb for a fit, then soldering in the flame of a Bunsen burner. Punch a small hole through the plate to take the pin in the crown, and replace in position on the root after trimming off the exposed edges. Now take a piece of thin pure gold, say No. 34 or 36, with ears as shown in Fig. 700; punch a hole through it, slide it over the pin of the Logan crown,

FIG 700

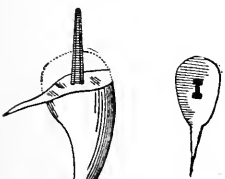


FIG. 701

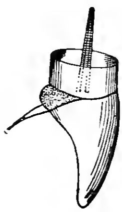
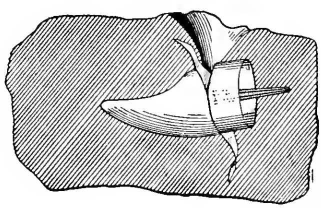


FIG. 702

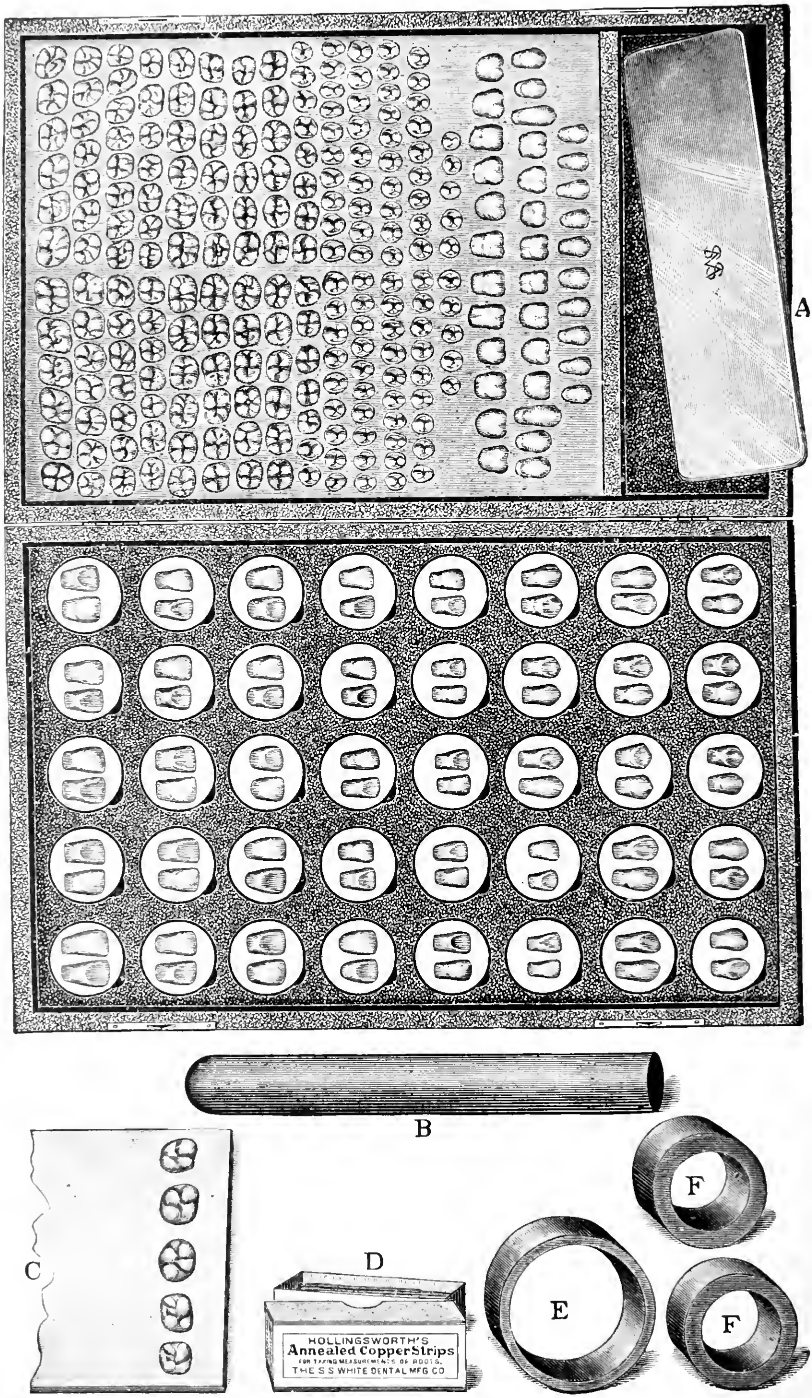


and burnish tightly to the base of the crown. (See Fig. 700.) Next warm the pin and place a sufficient quantity of Parr's fluxed wax around it as shown by dotted lines, Fig. 700. Replace the Logan crown on the root (with the cap in position), force home until the labial edges of root and crown meet, obtain the proper alignment, and cool and harden the wax by using a napkin with ice-water. Then remove the crown and cap together, held in proper relative position by the wax. (See Fig. 701.) Trim off the surplus wax and invest. (See Fig. 702.) Remove all the wax possible between the crown and the band, and flow 20-carat gold solder into the space. The wax which will necessarily remain, being fluxed, will carry the solder into every crevice and give the crown great strength. Finish the band and the soldered edges, and the result will be a strong and perfectly aligned crown.

The Hollingsworth System of Crown-and Bridge-work.—A system which affords greater range of ready application than any of its predecessors is that known as the "Hollingsworth." Its claims and description are thus given by its inventor:

"This system supplies, in the first place, a variety of forms for the various teeth great enough to cover almost any case and for the rare cases which cannot be suited direct it affords a ready means of making

FIG. 703


A
B
C
D
HOLLINGSWORTH'S
Annealed CopperStrips
FOR TAKING MEASUREMENTS OF ROOTS.
THE S.S. WHITE DENTAL MFG. CO.
E
F
F

the exact form required. There are in the set two hundred and four forms of cusps and thirty-six of facings for bicuspids and molars, and forty forms for incisors and canines. These last give both the labial and lingual faces. All the forms are exact facsimiles from nature, selected with great care to cover the widest range possible. They are made of metal, and are used as patterns from which to make dies or molds, as may be required, for the swaging of gold cusps or crowns. There is, therefore, no wear upon them, and they retain their shapes and sizes unaltered.

"The outfit for working these forms consists of a molding plate, three rubber rings, a sheet of asbestos 10 by 7 inches, a carbon stick for use in casting, and a box of Hollingsworth's annealed copper strips for measuring roots.

"This system permits cusps to be made either hollow or solid. Scrap gold can be used for casting solid cusps, and porcelain facings can be quickly inserted in crowns without investing; but perhaps its most important advantage is the exactness with which the fit and articulation of bridges are obtained and maintained."

THE CASTING PROCESS AND ITS AVAILABILITY IN CROWN WORK.

The introduction of this method has opened up a large field in this branch of prosthesis, but it must be employed with a full recognition of its limitations. Cast gold is not as strong as rolled gold, and a bridge of the former not so strong as one built up and soldered. The shrinkage of the metal in cooling must also be taken into account or failure on that score is sure to result.

The metal used for this work should be of high carat and of as great tensile strength and rigidity as possible. It should not be overheated. Coin gold seems to be well adapted for this purpose, as it possesses the qualities above mentioned and gives a good sharp casting.

All Porcelain Crown With Cast Base.—This, being one of the simplest and easiest crowns to make, will be first considered. The root for a crown of this kind requires little preparation, as compared with one for a Richmond or other banded crown. The face of the root may be irregular from decay or fracture, or it may have been ground down to meet the requirements of the case. In any event, it should be cut well beneath the gum line on the labial side, and on the lingual side enough to suit the requirements of articulation. The lingual side should, if it is possible, be beveled so that the base will overlap, thus giving additional support to the crown, and at the same time, serving to strengthen the root and overcome the liability of fracture. (Fig. 704.) The crown is then ground to conform to the size and shape of the root, and to touch it only at the labial side, leaving plenty of room between the balance of the face of the root and the crown to allow of a heavy base, as in Fig. 705.

The dowel, or pin, which is preferably made of iridio-platinum or platinized gold wire, is then adjusted and should be of sufficient length to go nearly or quite to the bottom of the hole in the base of the crown and

into the root to a depth at least equal to the length of the crown. (Fig. 705.) It is well to flow a little sticky wax around the post, between the base of the crown and the face of the root, at point *a* in Fig. 705, as the wax, of which the base is to be made, will adhere to the post better than it would otherwise.

The base of the crown is then lightly oiled, or coated very thinly with cocoa-butter to prevent the wax from sticking, and the base wax, which should be a little softer and tougher than the ordinary inlay wax, is softened and pressed around the pin at the base of the crown, which is then forced on the root and carefully adjusted in position. After the wax has been chilled, the surplus is carefully trimmed away, until it is perfectly smooth and flush with the sides of the crown and root. (Fig. 706.) The crown, together with the pin, is then removed from the root and the sprue wire attached, as in Fig. 706, by heating it just enough to imbed it slightly in the wax. It may be more firmly fixed by flowing a very small amount of wax around it at the point of entrance, after which the crown is removed.

The sprue wire is now placed in the base of the flask (Fig. 707), and the crown base is invested in the same manner as an inlay, painting the

Fig. 704

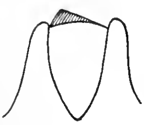


Fig. 705

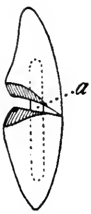


Fig. 706

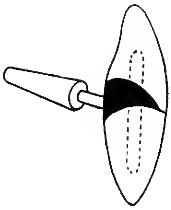
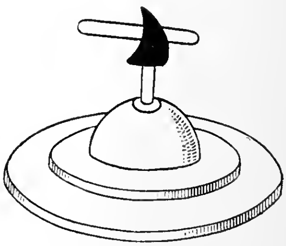


Fig. 707



investment very carefully so that there may be no air bubbles, which would be reproduced in gold in the casting and interfere with the fit of the base. After casting, it is cleaned and polished and adjusted to the crown and root. The base is first cemented to the crown, and after the cement has thoroughly hardened it is cemented in the mouth.

This makes a lasting crown when used singly, but it is not to be used for a bridge, as all bridge abutments should be banded.

Banded Crowns.—The caps for these crown can be made in the same way as for a Richmond crown, being carried well beneath the gum labially. The impression is taken and the model prepared in the usual way.

The crown is ground in the same manner, as already described in treating of the crown with the cast base, being beveled lingually and mesially and distally about half way to the labial face. (Fig. 708.) This allows a sort of a socket for the crown to set in and, at the same time, insures the correct position of the crown on the base.

The base of the crown is lubricated, so that the wax will not stick to it, and the wax is flowed in between the crown and the cap, until it is well

filled, after which it is carved flush with the crown and the band and the sprue wire attached, as in Fig. 706. The crown is now removed, leaving a wax base attached to the cap. It is then set in the flask base and invested and cast in the usual manner. The base should be polished with the crown in position, after which the crown is cemented to the base and kept under pressure until the cement has hardened. It is then ready for the mouth.

This method of procedure may be followed in making any crown of this type from molars to incisors.

Crown With Porcelain Facings.—In crowns of the Richmond type, where a porcelain facing is used, the cap and pin are made and fitted to the

Fig. 708

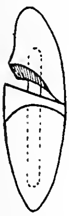


Fig. 709

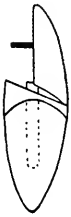


Fig. 710

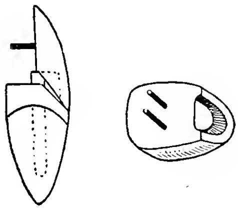
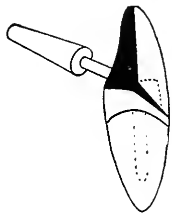


Fig. 711



root, and the facing ground to place, sloping it slightly more than the floor, so as to allow the gold to flow under the facing. (Fig. 709.) If there has been much recession of the gum, so that the band has to be sloped greatly, labially (Fig. 710), it is well to grind a step in the bottom of the facing, so that there may be a good base for it to rest on, thus rendering it less liable to be forced down the incline and fractured. (Fig. 710.) The facing is then lubricated on the lingual side, and held in place with a little sticky wax on the labial side, or a light wall of

Fig. 712

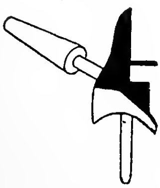


Fig. 713

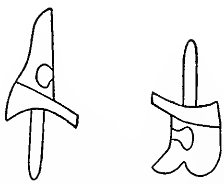


Fig. 714

plaster or modelling composition, and the lingual side is built up with hard inlay wax and carved and smoothed carefully. (Fig. 711.)

It should be remembered that the better it is finished in the wax, the easier it will be to finish the completed crown. The sprue wire is attached, as shown in Fig. 711, the facing carefully removed and small pins of graphite inserted in the holes left by the tooth-pins, leaving them long so as to be gripped in the investment. (Fig. 712.) Another way is to enlarge the pin-holes in the wax after removing the facings and dovetail them on the inside, as in Fig. 713. This can be easily done with a small coarse bur. It is then invested, care being taken to fill the pin-holes, if

they have been enlarged, and cast. After the casting has been made, the graphite pins are removed, the sides of the holes roughened, and the piece cleansed and polished. The tooth-pins are then lightly threaded or roughened and the facing cemented.

If the holes were enlarged and dovetailed, the pins may be flattened a little and then bent at right angles, as shown in Fig. 714, and cemented in place.

Casting Directly on the Facings.—In making a single crown or a small bridge, where it is intended to cast directly against the facings, great care must be used that the wax does not overlap the porcelain at any point. This is of the utmost importance, as if the wax is extended so as to grip the facings, the contraction of the metal on cooling will be certain to crush them. The wax should be carefully trimmed to the edges of the porcelain, and it is a good plan to clean them well by rubbing the edges with a piece of tape or cloth before investing.

Drying Out and Heating Up the Flask.—The flask should be dried out carefully and then brought to a very high heat throughout so that the facing will be red hot when the gold comes in contact with it. If the facing is cold, or but slightly heated, when the casting takes place, the rapid expansion of the platinum pins, taking the heat so much more quickly than does the porcelain, would fracture the facing. After casting, the flask should be allowed to become perfectly cold before opening, after which the piece is cleansed and is ready for finishing.

The crown, or the bridge, which has been made in this way will be satisfactory, providing there is little or no strain on the facings, but unless this is the case the method is decidedly objectionable.

In a facing which is reheated, in soldering or otherwise, the strength of the porcelain is diminished, and especially is this so if a mass of gold is forced upon it in a molten state. The piece may come out with the facings seemingly intact, but they have been weakened and in the majority of cases, if examined under a microscope, will show innumerable fine checks running all through them. It is far better not to subject the facings to this refiring, if it is possible to avoid it, as they are thereby rendered much more serviceable than they would be otherwise.

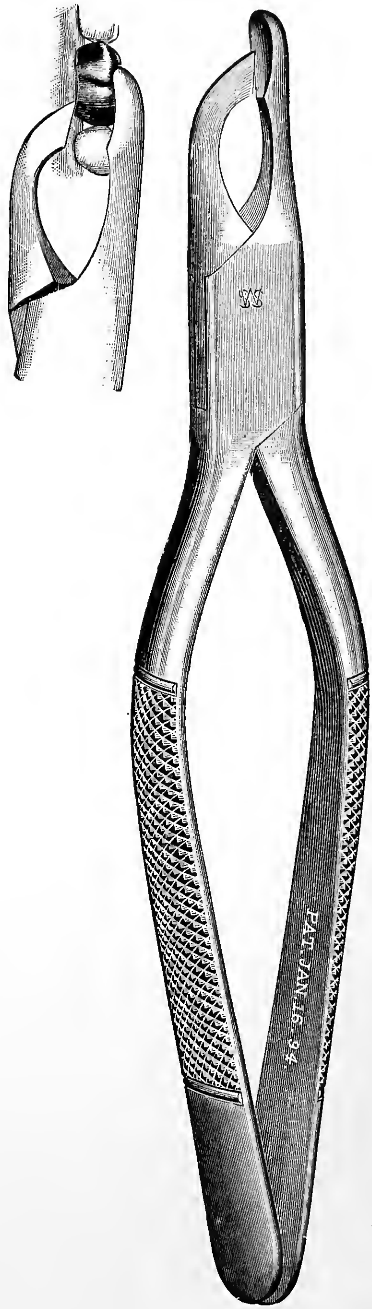
REPAIRING OF CROWNS.

When from any cause it is found necessary to remove a full gold crown from a tooth, if the crown has been properly fitted and cemented, it will generally be necessary to cut the band in order to get it off. This may be easily done with one of the crown slitters which are made for this purpose, as illustrated in Fig. 715. With one beak resting on the cusp and the other caught under the edge of the crown the forceps are closed, dividing the band all of the way to the cusp, when by giving a slight rocking movement, the crown may generally be easily lifted off. Should this not be the case, an instrument is passed under the flap and worked around the tooth to remove the cement and the band gradually loosened. A hatchet-shaped excavator can be used to do the cutting, the blade being drawn from the cervical edge to the cusp, until

the band is divided. A small wheel bur will do the work, cutting from the cervix to the cusp in the same way as with an excavator.

In repairing the crown, the cement is thoroughly removed and the edges of the break brought into close contact and soldered. If there is much loss of material at the site of the cut, a narrow strip of thin platinum or of pure gold is waxed over the line of division on the inner side of the cap, which is then filled with investing material and the broken edges united with solder.

Fig. 715



The repairing of a porcelain faced crown is a much more difficult operation. If the crown has been set with gutta-percha, it may be easily removed by grasping it with a heated pair of pliers or forceps, having first protected the lips and gums of the patient with napkins. If it has been set with oxyphosphate of zinc much more trouble will be experienced in getting it off. It will be necessary first to separate the cap from the pin. This may be done by passing a drill from the lingual side through the base of the backing and the floor of the cap to one side of the pin and then cutting the pin through with a very small fissure bur, after which the cap is easily pried off. To remove the post, the cement must be cut away from around it until it has become loosened. A very fine spear-pointed drill will do this best. The shank of one of the finest burs or of a Gates-Glidden drill, flattened on two sides and then ground to a spear point makes an excellent drill for this work, being smaller than any obtainable at the dental depots. The cement is drilled away close to the pin all around, inclining the drill toward the post at all times so as to weaken the root as little as possible by cutting into it. From time to time an

effort may be made to loosen the pin by grasping it with a pair of strong small nosed pliers and trying to rotate it. If it will not loosen, the drilling is to be carried deeper until it can be removed. The remainder of the cement is then removed from the canal and a new pin fitted to it. The palatal portion of the crown with the backing is then cut away (Fig. 716), the cap placed on the root and the pin waxed in place. The cap and pin are now removed, invested and soldered, after which the facing is ground, backed and the crown soldered.

There are several ways of replacing a facing in the mouth without removing the cap and pin from the root. A good way to do this where the remaining metal portion of the crown has sufficient thickness, is

FIG. 716

FIG. 717

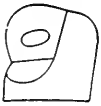
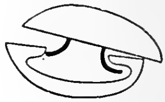


FIG. 718

FIG. 719

FIG. 720



as follows: the remnants of the pins are first cut off and ground flush with the backing and an impression taken covering the backing and floor of the cap, and a cast made of plaster, cement or Spence metal. A hole is then cut in the back of the cast large enough for the pins to enter freely. (Fig. 717.) The facing is then selected and ground to fit the cast accurately. The backing of the crown in the mouth is then cut out to accommodate the pins, care being used not to come through on the lingual side. The cavity is then deeply undercut all around, making it strongly retentive in shape. (Figs. 718 and 719.) The pins of the facing are then flattened at the ends and bent at right angles, one

FIG. 721

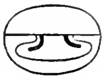


FIG. 722

FIG. 723

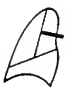
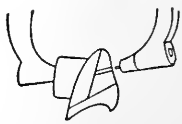


FIG. 724



being cut off so that it is a little shorter than the other so that when the long pin is inserted and the facing pressed as far to that side as it will go, the short pin will just pass through the opening in the backing. (Fig. 720.) The cavity is now filled with cement and the backing and floor covered. The long pin is first introduced, the facing carried to that side until the shorter one will enter. It is now pressed tightly in place and then forced back until the sides of the facing are even with the backing. This will bring the ends of both the short and long pins under the ledge of the cavity and when the cement has hardened, it will be impossible to remove the facing except by breaking it. (Fig. 721.)

Another method of repair in the mouth is by riveting a facing. It should first be fitted to a cast as described and a backing of tin foil or

paper fitted to it and trimmed carefully to the edge of the facing all around. This backing is then removed and placed in position over the gold backing of the crown in the mouth. (Fig. 722.) The holes in the backing will now show the exact position of the pins of the facing, and the holes may be drilled with a small spear-pointed drill the exact size of the pin. The holes are then countersunk from the palatal side and the pins cut off so that they will project only a slight distance through the backing. (Fig. 723.) The riveting is done with a plate punch. The facing is removed and the backing and floor of the cap covered with cement of about the same consistence as that used in setting a crown. A piece of lead or a thickly folded napkin is placed over the facing with the die side of the punch resting on this, and while the cement is yet soft, the pin is riveted by rubbing and burnishing with the punch end of the forceps until the countersink is entirely filled. (Fig. 724.) After riveting, any excess platinum of the pin may be ground away and the back polished. If a facing is carefully riveted, the holes not being too large, as strong a repair as can be made by any method is obtained. If the cement has been allowed to harden before the riveting is done it will be broken and crumble away.

Dr. Emory A. Bryant[1] describes a novel method of attaching a new facing. A tap and die the size of the tooth pins are necessary, together with a special countersinking tool and a screw-driver. The pins are cut from the old backing and holes are drilled the size of the pins of the new facing, and in the proper positions. With the countersinking tool held in a right angle hand piece, the holes are countersunk exactly to the outer wall of the backing. The nuts are made the size of the countersink. By means of the oiled die, a thread is cut on each pin of the tooth, and continued to the back of the facing, exercising great care that the pins are not twisted. The facing is set in position and each nut is loosely adjusted, then alternately screwed into place, drawing the facing close to the backing. The protruding portions of nuts and pins are then ground down and polished.

This method of replacing broken facings is very ingenious, but it is a question whether the cutting of a thread on such a small pin, will not weaken it to such an extent as to render it of little value where much strength is required. It is better if the full strength of the pin can be preserved.

RETAINING MEDIA.

The two materials commonly used as retentive media for artificial crowns are gutta-percha and the phosphate of zinc.

Each of these substances possesses properties which govern their employment. Oxyphosphate is adhesive, extremely hard, therefore, difficult of removal, and is more or less soluble in the fluids of the mouth. The greater the amount of acid present in the saliva, the greater the

[1] The Dental Cosmos, Vol. xxxvi., p. 469, et seq.

solubility of the cement. It disintegrates most quickly at the cervical margin, where acid formations are in greatest amount, and is somewhat porous. Protected from contact with the oral fluids, it lasts indefinitely.

Gutta-percha is almost unchangeable in the mouth, is plastic, is softer than zinc phosphate, and loses substance by attrition. It may be resoftened by heat, but softening becomes more difficult with age.

Therefore, zinc phosphate is selected for the retentive medium when it is protected from the fluids of the mouth, where such space exists as demands more rigidity than could be furnished by a mass of gutta-percha, and where adhesiveness is a desideratum, where support is to be furnished for a metal surface susceptible to change of shape, as, for instance, in a thin gold crown, where gutta-percha, if used, would by its elasticity permit change of shape in the band.

Gutta-percha is to be employed where the fluids of the mouth have access, where such a thin layer of retentive medium is required that its pliability does not affect its fixation, or where it may be desirable to furnish means for removal of a crown should this ever become necessary.

Thus in all crowns supported by bands or barrels which extend beneath the edge of the gum, zinc phosphate is the proper retaining medium.

Also in cases where a large space exists between crown and root; that is, an interior space not marginal, for marginal adaptation in all crowns must be perfect.

In those crowns which are placed upon posts which have been fixed in roots to serve as supports to porcelain crowns or faces, the retentive medium becomes practically part of the crown.

SETTING CROWNS WITH ZINC PHOSPHATE.

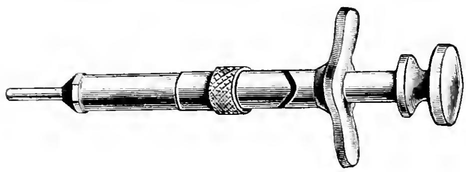
The zinc phosphate employed in the setting of crowns should possess the characteristics which would recommend the specimens to be used as filling material. It should, however, flow freely, and, as the difficulty of maintaining dryness is increased, it should set promptly and yet with sufficient deliberation to permit the accurate adaptation of the crowns. The operator should by actual test determine precisely the peculiarities of the particular cement he is to employ. Specimens of zinc phosphate differ so markedly in their behavior that it is always wise to make preliminary tests of each package.

It is advisable to set all pin crowns so that they can be removed without mutilating them, if at some future time it should be desirable to do so for the purpose of repairing them, or in case they should be needed as anchorages for a bridge. An excellent method of setting them so that they will be perfectly rigid and at the same time render them easily detachable, is first to give the pin and the inside of the cap and band a coating of chlora-percha. A solution may not always be at hand, and a convenient way to do this is to take a fine camel's hair brush, dip it in chloroform and then rub it on base-plate gutta-percha and paint the

cap and pin The solution will dry very quickly and the crown is then set with oxyphosphate of zinc. If at any time it is desired to remove the crown it can be easily done with a pair of heated forceps or pliers.

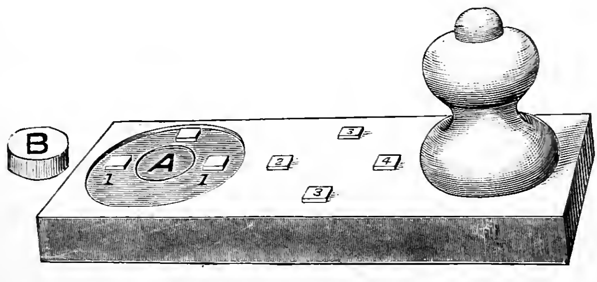
The Critenden cement syringe (Fig. 725) is a most useful aid in cementing crowns or bridges, especially where several pin crowns, either single or as abutment pieces are to be set at one time. It consists of a nickle plated brass cylinder, with the needle or tube small enough to enter the enlarged canal, and a brass plunger. There is an opening in

Fig. 725



the side of the cylinder for the introduction of the cement. The root is thoroughly dried and the cement mixed to the consistence of thick cream and placed in the cylinder. The piston is then put in and the end of the needle carried to the end of the canal and the cement forced into it, withdrawing the needle slowly at the same time. In this way, the apical extremity of the canal is filled first and any air which may be in it is forced out. A number of roots may be filled in this way in a few

Fig. 726



seconds and there will be ample time to put the crowns or bridge in place before the cement has set.

As soon as the piece is in place, the syringe is plunged into a basin of cold water and the piston worked back and forth to free it from the remaining cement while this is still soft. If the cement is too hard to be forced out it may be removed with the drill which comes for this purpose.

When gutta-percha is to be employed, it is necessary that the several parts shall be at a temperature which will permit the ready, deliberate and accurate adjustment of the crown and gutta-percha to the root.

A satisfactory method of manipulation is as follows: a napkin is

adjusted so that the root is protected from moisture; the canal is wiped out with caustic pyrozone.

The crown is laid upon a gutta-percha heater (Dr. How's steatite slab is useful for this purpose), a piece of tough gutta-percha is laid beside the crown. and when soft is pressed out between the fingers into a sheet, which is wrapped around the heated post. The root-canal is wiped out with oil of cloves or water so that gutta-percha will not adhere to it, and the heated crown and softened gutta-percha are pressed into position. If an excess of gutta-percha has been applied, the surplus will be squeezed from beneath the outline of the crown. This excess is to be trimmed away by means of sharp scissors. If there has not been sufficient gutta-percha attached to the post, more is to be added to that on the post and the crown reapplied, and then the excess trimmed off. The crown is returned to the heater, which is again held over the flame until the fusible metal melts. A fresh napkin is placed in position; the root is wiped out with alcohol and dried by means of a hot blast. It is then wiped out with one of the essential oils. A small sheet of softened gutta-percha is added about the post, and when the crown and gutta-percha are thoroughly heated, the crown is seized between the fingers, protected by a napkin, and pressed into position. A heated crown adjuster is now applied to the crown, and it is forced into position; the excess of gutta-percha is squeezed out at the margins of the crown.

CHAPTER XVII.

AN ASSEMBLAGE OF UNITED CROWNS (BRIDGE-WORK).

By H. H. Burchard, M.D., D.D.S. and F. A. Peeso, D.D.S.

A dental bridge is essentially a continuous masticating surface anchored to supporting abutments at two or more points of its length, the fixation and retention of the device depending upon anchorage on or in the natural teeth; any support derived through contact of the appliance with the natural gum is purely secondary. The method and variety of support are the direct reverse of those of an artificial denture mounted upon a plate, for here the primary support is by the natural gum, and any further support derived through attachment to the natural teeth is merely adjunctive. The term "removable bridge" is gradually being extended to include devices which receive their support both from the membrane and from the teeth or roots.

The appliances in contemporary use which are included under the head of "dental bridges" comprise a multitude of devices, the construction and support of which depend upon a few principles. The many different forms are modifications of a limited number of types, the differences between many of apparently diverse types being merely technical and not those of mechanical principles.

The natural teeth or roots supporting the bridge are called its "abutments," the crowns placed over them or the bars anchored in them, the "abutment pieces." The intervening portions of the fixture are known as "the body of the bridge," and the several pieces of which it is composed, "the dummies."

History.—Devices which might be classed as dental bridges are probably as old as the earliest attempts at dental prosthesis. The placing of a band of metal about one natural tooth is the simplest means for supporting an additional tooth, and probably the first attempted.

Among the archæological remains of the Etruscan life are found devices which bear a family resemblance to bridge-work.

The present varieties included in the generic name of dental bridges are the evolution of processes and type suggested and made early in this century. As an example of an early device bearing a close resemblance to a contemporary appliance, Dr. W. F. Litch [1] gives a cut from the work of F. Maury (1828), showing six anterior teeth anchored in the roots of the canines by means of two posts placed in the enlarged pulp-canals.

[1] American System of Dentistry vol. ii., Fig 758.

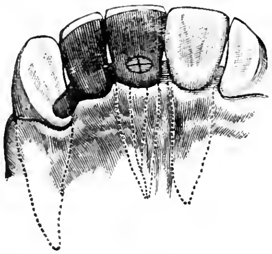
In April, 1855, Dr. Wm. H. Dwinelle[1] described the progenitor of the modern pin and plate bridge, together with the prototype of another form of bridge in present use: "After the root is filled with gold...... and properly finished, an impression of its surface is taken in wax, from which castings are made, and from these plates are swaged. These are adjusted to the tooth and a gold pivot soldered to the upper surface. A plate tooth is now skilfully adapted to the fixture, when it is ready for use. In this way a plate may be carried across an intervening space unoccupied by roots, and an unbroken row of teeth mounted upon it."

In January, 1871, Dr. Benj. J. Bing applied for a patent for a bridge devic to be anchored by wire extremities into cavities in the natural teeth.

A form of removable bridge was introduced by Dr. W. G. A. Bonwill in 1873 (Fig. 727).

The revival of bridge work, or the modern ideas of these forms of appliance, arose with the advent of the barrel and collar crowns. This variety of crown made and applied early in the century, appears to have had very limited employment until its elaboration by Dr. C. M. Richmond. The primary principle involved was, as stated, known and applied for many years; it is but thirty years, however, since the general adoption of the idea.

FIG. 727



In its simplest form a dental bridge consists of two or more crowns bearing between, and rigidly attached to them, substitutes for the crowns of the intervening natural teeth which have been lost. The primary object sought has been disuse of a plate, and such firmness and immobility as would furnish a better means in mastication than is possible with a plate denture.

CLASSIFICATION OF BRIDGES.

Dental bridges may be divided into two primary classes—fixed or removable.

Fixed bridges are those which are so attached to the abutments that removal of a properly fitted and adjusted piece is not practicable without more or less mutilation of the abutment crowns (Fig. 728).

Removable bridges are those the supporting crowns of which may be detached from the abutments without disturbing the integrity of the appliance.

Class 1 may be subdivided into sub-classes according to the method and means of anchorage:

[1] American Journal of Dental Science

Sub-class 1: Those attached to the abutments by means of collar or barrel crowns (Fig. 728).

Sub-class 2: Those in which fixation is secured by means of metallic bars anchored in the crowns or roots of teeth.

The features of both sub-classes may be combined in one piece, a bar anchorage at one extremity and a collar or barrel crown at the other (Fig. 729). Devices of the varieties of Dr. Litch's pin and plate bridge belong to sub-class 2; the open-cylinder partial crown terminals to sub-class 1.

The usual forms of removable bridges have abutment crowns made of cylinders, which telescope over metallic ferrules which have been permanently attached to the abutments. This form of bridge was devised to facilitate removal when repair of the piece became necessary; to permit of occasional removal, so that the bridge might be perfectly cleansed; to furnish a method of attachment when the abutment teeth were in such malposition that a fixed bridge could not be attached without undue mutilation of natural crowns.

Fig. 728

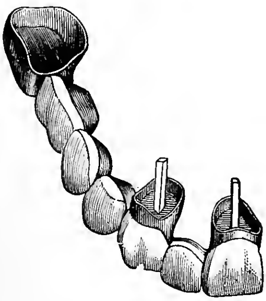
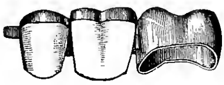


Fig. 729



The introduction of the removable bridges has negatived several of the objections urged against the practice of this work. First, the want of perfect cleanliness, since removable bridges may be detached when necessary and receive a perfect cleansing. In case of repair being necessary, the piece may be removed without mutilation of the abutment crowns. It furnishes a means for bridging spaces enclosed by overhanging teeth. These bridges possess so many advantages over the fixed variety that it is probable they will largely supersede the latter.

A type of device somewhat resembling a bridge has been constructed and described, which combines some of the features of both bridge and plate. Extending from the terminal abutment pieces of a fixed bridge are arms or wings resting upon the gum and supporting one or more artificial teeth on each of them. The mechanical principle involved in this device is faulty. The plate pieces to furnish any material support must be of such size as to render the appliance highly objectionable hygienically; and if too small to serve as effective auxiliary supports, the abutments are overstrained.

In judging of the merits and demerits of this phase of prosthesis, it

would be manifestly improper to accept all the claims of the enthusiastic advocates, or to be governed by the opinions of its pronounced opponents.

The advantages claimed for bridge-work are the removal of many of the deficiencies associated with plate dentures. First, the bridge is immovable; second, there is no interference with articulation; third, teeth may be replaced without the necessity of wearing a cumbrous plate. The several advantages enumerated by advocates may be all summed up under these three headings.

The objections urged against bridge-work in the past have been in great measure removed; others remain. It does not restore lost gum contour, except with those devices known as plate bridges. It is uncleanly; the space existing between portions of the bridge surface and the natural gum are frequently inaccessible to the tooth-brush and contain decomposing food débris. Teeth are often necessarily mutilated to serve as correct abutments, and some operators advocate the devitalization of the pulps of the teeth thus prepared for abutment, on the ground that their mutilation and the fact that they may be subjected to a greater mechanical stress than they can safely bear, is liable to cause the death of their pulps with the phenomena which usually accompanies such a result, and which would be more difficult to relieve and treat after the bridge was permanently fixed.

The intrinsic merit of properly constructed bridge-work is undoubted. Many of the objections stated above do not attach to properly designed and constructed pieces; they are based upon such practice of bridge-work as is now regarded as unjustifiable.

It is to be recognized that neither bridge-nor plate-work is of universal application; each case presents indications which should determine what form of prosthesis is applicable.

The work has unquestionably a great field of useful application: cases there are in which this type of fixture is a well-defined need, and others in which it is clearly contraindicated.

The first inquiry of the operator should be, Is a bridge demanded by the conditions present? that is, Does a bridge device possess for the case in hand sufficient advantage over a plate denture to render its use an imperative indication? Upon this point turns the entire subject of the wisdom or unwisdom of bridge-work.

The student is assured that in the practice of this special field he will find application for an exhaustive knowledge of dental pathology, therapeutics and mechanics, combined with rare manipulative ability; in point of fact, the work should not be done unless the operator possess this degree of knowledge and skill.

The requisites for its correct practice mark the mechanical and physiological aspects of bridge-work.

Mechanical Aspects.—Under the mechanical aspect are included all considerations of resistances to stress and the effect of stress as expressed in the mobility of the bridge, of any part of it, or of its abutments. The same considerations governing the mechanical resistance of roots

or teeth when serving as bases for artificial crowns, apply with increased emphasis when they are to be the abutments of a bridge piece.

The student is presumably familiar with the anatomy and the anatomical variations of the teeth as to their forms, structure, and positions.

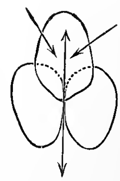
Any stress greatly in excess of the amount normally borne is a menace to the integrity of a tooth's retention. The increased mechanical stress reacts physiologically, and by a pathological process the tooth is loosened and lost.

The vertical is the only direction of force which does not tend to mechanically dislodge a tooth, and it is one to which teeth are rarely subjected alone. As a rule, teeth protest against stress received in any direction other than that due to their anatomical forms and positions. Incisors are by these factors designed to meet and resist stress—to move in one direction, either outward or inward. The broadest aspect of their root is anterior, offering at this part the greatest resistive surface.

The canines receive the force in two directions, each at an angle with the axis of the tooth: the resultant of the forces (the direction of the movement of the tooth) is between the two forces. The movement will be according as the greater impact is anterior or posterior (Fig. 730).

The bicuspids normally receive three main lines of force—an outward, an inward, and a vertical: the outward and inward forms are the resultants each of two forces acting upon the cusps at an angle with the axis of the tooth.

Fig. 730



The muscular force being equal, the longer the cusps the greater will be the lateral stress; also the broader the cusps (the farther their external walls are removed from the axes of the teeth) the greater stress there will be in all three directions.

The molars also receive force in three main directions, but the lateral forces are the resultants of several lines of force according to the sizes and positions of the cusps.

The resistances to these stresses are through the forms, number, sizes, and structure of the roots, and also of their supporting structures.

Dr. Bonwill has demonstrated a relationship between the lengths of the cusps and the amount of over-bite, and as a consequent the extent of the contact of the cusps in mastication. The greater the over-bite the greater surface of contact there must be, and, other things being equal, the greater mechanical stress. This is an important consideration, and one to be constantly borne in mind in the making and adjusting of crowns and bridges.

No absolute, or perhaps even approximate, rules can be formulated as to the amount of strain any single tooth will bear: attempts at the formulation are delusive. Given two central incisors, the amount of resistance either will afford depends, first, upon the anatomical form and support of each, and their relative positions to their antagonists, and is governed largely by the physiological condition of each. Alter the relations in any particular, and the resistance is correspondingly modified.

In the upper jaw, the central incisors are stronger teeth than the laterals. The canines are more firmly implanted than the bicuspids, or any of the anterior teeth and constitute the best abutments. The bicuspids form good anchorages if too much is not expected of them. The first and second molars are very strong and make good abutments, but the third molars are more uncertain and cannot be depended upon to the same extent as the first and second. There are many times however, when these teeth are exceptionally firm and strong and will do their share of the work in supporting a bridge: but they should be examined carefully before deciding to utilize them. One probable reason for their frequent failure to render satisfactory service is the fact that as they are situated so far back in the mouth and are consequently so difficult to get at for trimming, this latter operation is not thoroughly done and the bridge fails. The fact of their difficult accessibility should make the operator more careful and painstaking in their preparation.

In the lower jaw, the lateral incisors are stronger than the centrals which are the weakest teeth in the mouth; notwithstanding this fact, the centrals are frequently of great value as abutments in those cases in which the placing of a bridge would be impossible without their use. The relative strength of the other teeth in this jaw, is about as in the corresponding teeth of the upper jaw.

The form of the arch has a great deal to do with the carrying capacity of the teeth. A bridge which in one mouth would be of the utmost value to the patient, in another, with exactly the same anchorages, all in an equally good condition, but with the arch differently formed, might prove impractical or useless.

By uniting or splinting together several teeth, as in a bridge piece, the movement of each tooth is modified or restrained, and by such fixation two natural teeth are frequently found to withstand successfully more force than the sum of their individual resistances. As an illustration observe a common condition in which a bridge is applied—a lower second bicuspid and a third molar serving as abutment teeth. If these teeth be healthy and have firm attachment, fixing to them a rigid bridge piece prevents the tendency toward antero-posterior displacement, one of the strongest elements tending toward their loss; they are held by the bridge so that the only possible movement is lateral.

If the lateral stress be correctly governed, such teeth may safely bear crowns upon their own roots, and support intervening crowns, filling the space between them, for a longer period than were a bridge not applied.

One of the most common faults of bridge-work is, however, increasing strains without due regard to the available resistance.

Using the same bridge for illustration, the abutments are subjected to the amount of stress normally borne by four teeth. It depends upon the directions of the root-axes whether the resistance of the abutments when barred together is increased in the same degree as the stress. Their antero-posterior movement is effectually checked, but if the roots

of the teeth have parallel axes, both are free to react upon lateral stress. While abutment teeth submit without protest, as a rule, to the direct vertical force of mastication, occasionally there will be found a progressive degeneration of the pericementum, which causes loosening of these teeth.

The lateral stress is the one tending to dislodge bridge fixtures, and the tendency to displacement is increased in the ratio of this stress hence the longer the cusps, and the more accurate their occlusal union with the antagonizing teeth, the greater the stress upon the abutments.

Bridge-work should be constructed upon sound mechanical principles: to be successful as a piece of engineering work, all designs are to be founded upon those principles. These fixtures are literally bridges, a continuous surface supported by rigid abutments, designed to bear

Fig. 731

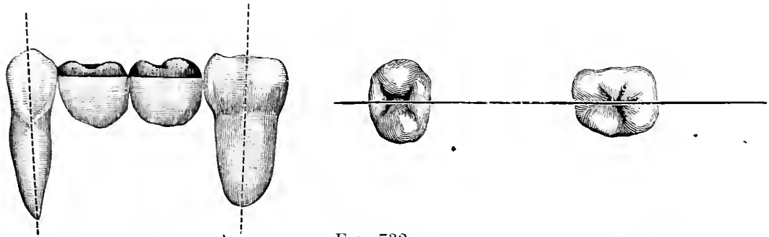
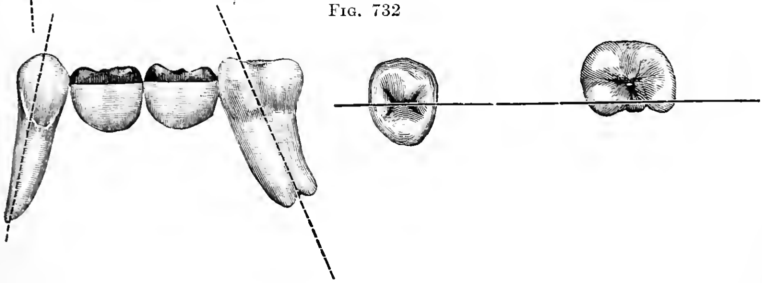


Fig. 732



safely the amount of stress it is calculated the piece will be subjected to. The calculations involve the strengths of abutments, crowns, and body of the bridge. Violations of sound engineering principles are common in suggested devices: the students should examine carefully all proposed designs and select only those which are mechanically good.

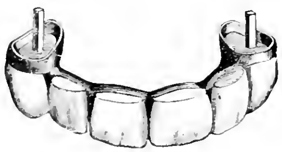
An engineer recognizes that the stability and permanence of his bridge depends primarily upon the strength and position of its abutments. If these be badly built or poorly sustained, the bridge fails; so that bases are selected and prepared, abutments built, with a due regard for the weight they are to sustain, the resistance they are to afford.

With dental bridges, utilizing any but sound teeth or roots, those free from pericementitis or abscess,is equivalent to an engineer building abutments in a marsh without piles.

In designing a bridge note the directions of the least and greatest resistances, and apply the strains accordingly, and mold the articulation so that the greatest force shall be opposed to the greatest resistance and *vice versa*. To illustrate: teeth which have their axes parallel and in the same plane (Fig. 731), all other things being equal, will withstand less stress than were the axes not parallel and in different planes (Fig. 732); that is, when the teeth in both cases are serving as bridge abutments: with parallel axes, when one abutment moves in the direction of least resistance its fellow abutment moves with it; but if the axes be not parallel, when one abutment is subjected to stress in the line of least resistance its fellow is receiving the stress in a line of greater resistance.

Another illustration is found in a common form of bridge—two canine roots supporting artificial crown subsitutes of the six anterior teeth (Fig. 733.). With all of the posterior teeth in position the amount of strain on the abutments is governed first by the lengths of the crowns, the leverage on the roots; next upon the amount of over-bite or the extent of incisive action occurring before the occlusion of the posterior teeth equalizes the forces. In the ratio of the stress is the demand for increased resistance: such cases form bulkheads, and if the displacing force be great, the ends of the bulkhead require reinforcement through additional abutments.

Fig. 733



To ensure the stability of a bridge it should be so made and so attached to its abutments that neither bridge nor any part of it has any movement independent of the abutments. Violations of this rule are found where caps are made of too thin metal, which by stretching or breaking permit slight loosening of the piece; the retaining cement is worn away piecemeal, and the space left is filled with fermenting débris: decalcification of the enamel and caries ensue.

With decreasing amount of resistance offered by the abutments should be a decrease of the extent of masticating or incisive surface; for example, two abutment crowns, a firmly fixed molar and canine, having healthy root support, may have the original amount of masticatory surface restored; but if the fixation of the abutments be less rigid or not in so good a physiological condition, the amount of the surface should be diminished.

It is not possible for one to specify all of the situations for which bridge-work is suitable, but we can endeavor in a general way to give an idea of what may be expected of the different teeth. No two cases are alike and each one should be studied by itself and a judgment formed according to the conditions existing in the individual case. We shall begin at the anterior part of the mouth.

Where the two lateral incisors have been lost, the central roots may be safely trusted to support both lateral dummies, but it would not be reasonable to expect them to do more. Where the centrals are missing, the lateral roots are usually sufficiently strong to carry a bridge

restoring the former, but in the case of an exaggerated V-shaped arch, the leverage of such a bridge might cause sufficient strain on the roots to dislodge them. A right central and left lateral will carry the left central and right lateral dummies and *vice-versa*. Where all of the incisors have been lost, if the arch is broad and the canines stand well apart, so that the teeth to be restored may be placed in nearly a straight line, a serviceable bridge may be made with a reasonable expectancy that it will last for many years.

Where the arch is very narrow or V-shaped and the canines are close together, so that the incisors have to be placed in a marked curve outward, projecting far beyond the line of the abutments, it would be risking a great deal to trust to the canines alone to carry such a bridge. If the bridge is extended so as to take in the bicuspids, it will make a much stronger piece, as these two additional anchorages will render it more rigid, and the resistance of the broad masticating surfaces of the bicuspids will make it less liable to tilt upward in the front. These conditions obtain more especially in cases of fixed bridges.

Where the six anterior teeth are lost, it is perhaps as well to give up the thought of bridge-work and to trust to a plate; however, under certain conditions a satisfactory removable bridge might be made for the case.

To place a bridge from the canine to the first molar, or even to the the second, is good practice, and at times it might even be extended to the third. The first or second bicuspid and the second or third molar will give good support. Where all of the molars are lost, they can only be restored with the removable type of bridge.

In order to restore the full set of teeth in the upper jaw, there should be at least four good strong roots to serve as abutments, as for example, the two canines and a first or second molar on each side. Where the two central roots are also in position, of course, they give greater strength to the piece and each additional root adds just so much to the chances of long life for the bridge.

A larger bridge may be placed on the same number of roots in the lower jaw than in the upper, as, having gravity in its favor, the choice of a saddle piece is possible, which could not be thought of in the upper jaw. Of course, it must be made removable.

Physiological Aspect.—The physiological aspect of bridge-work, although belonging properly to works upon dental pathology, must form part of every treatise upon such a combination of surgery and mechanics as bridge-work represents. It includes the consideration of all of the vital relations of the abutment teeth, the contiguous parts, and, it may be, of more general vital relations. Anything directly or indirectly bearing upon the subject of dental hygiene is an item for consideration in the pursuit of this work.

The first question is that of the physiological resistance of the abutments, and the danger, immediate or remote, of any disease process occurring in or about them. These include the possibilities of enamel decalcification, caries of the dentine, eburnitis, any stage or degree of

pulp irritation or inflammation, and any variety or degree of pericementitis. The possibility or probability of any one or more of these conditions arising must be a governing factor in determining the form of bridge to be applied.

Due consideration must be given to the possibility of disease process of the soft tissues—whether through too great or improper character of contact the gums be irritated by pressure or the contact of sharp edges, or the forming of spaces in which decomposing food may act as an irritant to mucous surfaces.

The decalcification of an enamel surface embraced by a portion of the bridge arises from lactic acid, the product of a specific fermentation of starchy foods gaining access to surfaces from which it is not removed, due either to the carelessness of a patient or to his inability to remove it owing to the peculiar situation.

Under narrow bands or where the retaining cement is exposed to the access of the fluids of the mouth, after a variable length of time it is mechanically dislodged, or it may be dissolved, leaving a space which fills with fermenting materials inaccessible to the tooth-brush. Pockets made by some surface of the bridge and an uncovered enamel surface become filled with fermenting deposits, which if not removed produce decalcification of the enamel surface. If these spaces remain undetected, caries follows, and it may be exposure and disease of the pulp, and subsequently of the pericementum.

Bridges should be so made and so placed that even less opportunity is given for the action of the products of fermentation upon tooth-tissues than before the placement of the bridge.

Any part of a tooth's surface which, through the fixing of a bridge, is placed beyond the access of the ordinary cleansing agents employed by patients should be protected from the ingress or contact of ferments or fermentable material by having a portion of the bridge act as an impenetrable and impermeable shield.

Another possible source of disturbance, one which may affect the nutritive functions of the pulp, will be found in teeth which have been denuded of enamel by their preparation to serve as abutments. The pulp may receive abnormal stimulus through the irritation of the contents of the dentinal tubuli or have an increased conduction of thermal influence, and secondary deposits may occur in the pulp.

The question of subsequent pericementitis in an abutment tooth, if the tooth be pulpless, depends largely upon the thoroughness with which the pulp-canal and dentine have been sterilized, and the completeness with which an impenetrable barrier has been placed between the pulp-canal and the tissues of the apical region; second, upon the former condition of the root, as a part once inflamed has an increased susceptibility to a recurrence of inflammation; third, overstraining the abutments, causing a chronic pericementitis and a gradual loss of the alveolar tissues; fourth, the existence of a dyscrasia which may in the future cause phagedenic pericementitis. Should any of the pathologic states be present, they must receive appropriate treatment before the

fixation of the bridge. Should they arise subsequently, each must receive therapeutic aid.

The muco-periosteum of the alveolar ridge most suitable for the contact of bridge pieces is that exhibiting firm texture and pink color. When placed in mouths exhibiting a catarrhal condition increased care is demanded that there be no inaccessible pockets in which fermenting material may find lodgement.

When the retaining medium of a bridge is zinc phosphate, it should be so protected by the bridge that the fluids of the mouth have little or no access to it.

Contact of any portion of a bridge with the natural gum should be of such a nature that there is established no source of irritation to it,

Fig. 734

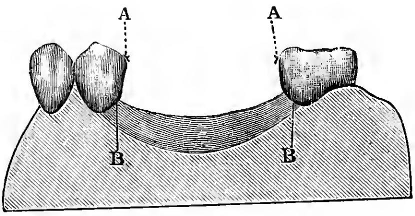
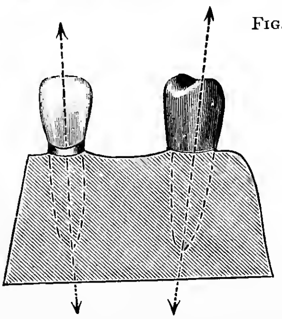


Fig. 735



either through roughness, sharp edges, undue pressure, or inaccessible pockets.

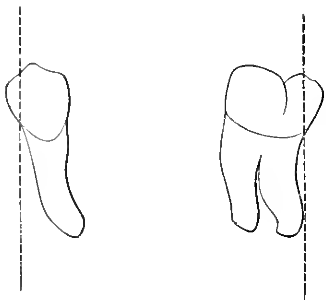
Preparation of Abutments.—First and most important, any root or tooth which it is designed to make the abutment of a dental bridge should have such preliminary treatment as will bring it to a condition of health. The directions given as to the preparation of roots for the reception of artificial crowns apply with redoubled force when these roots are to be abutments. The same requirements as to perfect adaptation of individual crowns also obtain when such pieces are to serve as the abutment crowns of bridges. The contact of every crown edge with its base should be perfect, and each crown should represent as carefully made and adjusted a piece as were the same crown to stand alone.

After all preparations of the bases have been made, so that single crowns may be properly adapted, there arises the consideration of the

mutual relations between the individual crowns. It is evident that as these pieces are to be rigidly joined to one immovable piece, the abutments must be so shaped as to permit placing them when so joined. The next consideration is, therefore, the dressing of the walls of the abutments until they are parallel or less than parallel, for it is also evident that if the distance *AA* be less than *BB* (Fig. 734), joined cylinders which shall slip over *A A* will not be in contact with the points *B B*; and this latter is an essential condition in properly adapted abutment crowns. (See also Fig. 736.) With post crowns it is evident that the axis of the root-canal, the root-walls covered by the collar, and the walls of the other abutment must all be parallel or they cannot be perfectly set when rigidly united. The placing of a wire in the prepared root-canal will assist in a judgment of this. The lack of parallelism is shown in Fig. 735.

The extent of the lack of parallelism between the axes of the abutments are noted before preparing the latter for the reception of the abutment crowns. A pair of accurate callipers will be found useful to make measurements to determine the amount of dressing required. Applied first to the longest distance between the abutments, usually at the necks of the teeth, this length is laid upon the parts with shortest distance. The portions of the tooth necessary to equalize the lengths are then dressed away. Should the teeth diverge, the shortest distance is first measured, and the dressing of the walls proceeded with as before.

Fig. 736



To allow of slight aberrations in adjusting it is usual to reduce the walls to something less than mutually parallel lines.

Requisites of a Correct Bridge.—The first requisite is that a dental bridge must be regarded as a prosthetic appliance in its fullest sense: it should restore as nearly as possible lost form, appearance, and function. It should, therefore, restore the general contour lost through the loss of the teeth, and reproduce the forms of the natural crowns. The pieces should be constructed for æsthetic effect with the same care as with a plate denture. The teeth should be selected with the same regard to their proper sizes, shapes, and colors as with plate dentures. The same care is to be exercised in accurately adapting crowns as when these fixtures are made and applied as single crowns. These details are frequently ignored or deemed of minor importance—a view to which the student should by no means subscribe. The masticating surfaces are to be so formed that they will occlude perfectly with the antagonizing teeth; moreover, so that they shall effectively perform the work of actual mastication to an extent commensurate with the resistance of the abutments.

It is unwise to make the restoration in this particular too complete:

that is, by restoring full cusp lengths and full occluding surfaces, as would be the case were an anatomical articulator used and the teeth perfect anatomical representatives of the lost organs. The occluding surfaces are given a smaller area, and the cusps made shorter than with the natural teeth, so that the vertical and lateral forces upon the abutments are lessened to the required degree. This only applies to cases where all of the posterior teeth on both sides of the mouth are to be restored. If the natural teeth are all in position on one side of the mouth, in a bridge restoring the lost molars or bicuspids on the opposite side, the cusps should be made to correspond to the cusps of the natural teeth. When the jaws are in normal closure, however, the occlusion should be perfectly accurate or else the usefulness of the piece is lessened.

If possible, every portion of the bridge and abutments above the gum line should be easily accessible to the bristles of a tooth-brush. Tooth-substance should form no wall of a pocket inaccessible to the same implement. The bridge should cover and seal such surfaces. It should be sufficiently rigid in all its parts, and be so firmly attached to its abutments that abutments, bridge, and all its parts are a rigid piece, having not the least movement except as a single piece. It is essential that the abutments or their crowns have no movement upon one another. This necessitates that each crown shall be in itself sufficiently rigid to resist any change of form through the stress of mastication. It is not alone necessary that a crown shall fit an abutment perfectly; it must continue to do so.

As stated earlier in this chapter, there should be in the placing of a bridge a diminution rather than an increase of the opportunities for disease process arising. All edges which come in contact with the soft tissues should be smoothed and rounded. Every surface of the bridge should be free from inequalities or mechanical blemish of any kind.

THE MANUFACTURE OF DENTAL BRIDGES.

There are involved in the making of a bridge three sets of manipulations: first, the making of the abutment crowns; second, the manufacture of the intervening dummies; and, third, the uniting of the several parts into one rigid, highly finished piece. From beginning to end it includes a series of small but important details. In the degree that care and attention are devoted to these minutiæ will be the accuracy of fit and finish of the completed bridge; neglect of them may be followed by blemish or even by disaster.

Æsthetic considerations are too frequently ignored in this class of work, but they are equally important in this as in any prosthetic operation. The completed piece should present a restoration as nearly as possible of the forms, color, size, and positions of the natural organs, and should be so articulated as to restore the lost masticating surfaces. Unnecessary exposure of gold is to be avoided, and yet the several

porcelain pieces are to be so guarded that they serve merely for the restoration of appearances, receiving themselves no direct force, the latter bearing only upon masticating surfaces of gold. By this means fracture of the porcelain becomes a remote possibility.

We shall now consider the making of a bridge and shall select as a common type, one of two full gold crowns, or of one full gold crown and a Richmond, carrying one or more dummies. The abutment pieces having been adjusted to their respective positions, the impression and articulation are taken and the cast prepared in the manner already described.

In selecting the facings for the case it is desirable to choose them of such length that when they are ground into place, the necks will just touch the gum lightly and the occlusal edges will be in contact with the antagonizing teeth. They are ground to follow the gum line and should not be in actual contact with each other. After they have been ground into place, a wall of plaster is built up on the buccal side of the cast to retain them in position. After the plaster has hardened the facings are removed, and their occlusal ends ground off about one thirty-second of an inch and at an angle of about forty-five degrees with the

Fig. 737

Fig. 738

Fig. 739

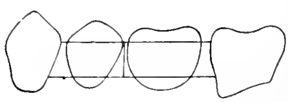


Fig. 740

back of the facing. (Fig. 737.) The line of their occlusal ends should be continuous, that is, the bevel of one facing should not be higher than another. The facings are then to be backed and for this purpose, platinum, crown metal or pure gold may be used. The gold will have a tendency to lighten the color of the facing and give it a slightly yellower cast, while the platinum will tend to darken it and confer a bluish tint. If the backing is of platinum, it may be very thin, about three one-thousandths of an inch. It should extend from the inner edge of the bevel at the occlusal end, to and about one-sixteenth of an inch over the lower edge where it has been ground to fit the gum. (Fig. 738.) The backing of each facing should touch or slightly overlap that of the one next adjoining and those of the end facings should be in contact with the abutment crowns. (Fig. 739.) The pins are flattened with a pair of pin-roughening pliers, and are bent down over the backing, thus pressing it close to the facing. The facings are then waxed together and to the abutment crowns with hard adhesive wax, a piece of oiled paper being placed underneath on the surface of the cast to prevent their attachment to it. The wax should be built up high enough to support the cusps for the dummies. (Fig. 740.) Suitable solid cusps

are then made, ground or filed to fit the bevel of the facings, and fastened in place with adhesive wax. (Fig. 741.)

The bridge is now ready for investing and soldering. It is taken from the cast, the inner cap being removed also if it be a removable bridge, and the inside of the abutment pieces filled with the investing material and the whole bridge partly imbedded in it with the facings down. The investment should come over the backings which extend beyond the lower angle of the facings, holding them in place and preventing their springing up. (Fig. 742.) The investment should come nearly to the lingual edge of the cusp (Fig. 742), and should be small, and only large enough to hold the parts together. The abutment crowns are partly covered to protect them from the flame.

In grinding the facings for the dummies for any of the six anterior teeth they should be made to set closely to the cast, and after they are properly fitted a wall of plaster is made on the labial side. The facings are then backed, the backings extending over the beveled portion at the neck and about one-sixteenth of an inch beyond the incisal edge (Fig. 743), and the pins flattened and bent toward this edge close to the back-

Fig. 741

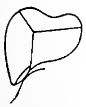


Fig. 742

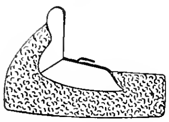


Fig. 743

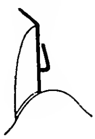
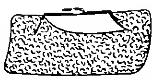


Fig. 744



ing. In investing, the investment should cover the extending portion of the backing to prevent its warping. (Fig. 744.)

Bridges of three or four teeth may be soldered in one piece, but large cases should be soldered in sections. This is because the contraction of large masses of solder when the piece cools has the effect of disturbing the relation of the abutment pieces, and the bridge in consequence has its fit impaired. A full bridge of twelve or fourteen teeth should be soldered in three or four sections. If in three, the incisors may be soldered in one piece, and the sides from the canine back separately. If in four sections, the central, lateral and canine of each side separately and then the side bridges. The different sections are then finished and polished except where they are to be united. They are then replaced on the cast, waxed together with adhesive wax and a strong iron or brass wire bent to conform to the lingual side of the bridge and waxed firmly to the different parts. This will hold them firmly in their proper relative positions and prevent their springing while being removed from the cast and invested. The bridge is then invested, the divisions between the several sections being freely exposed and the parts united with the same, or a slightly lower carat solder than has been used in the previous soldering. When the investment has cooled, the bridge is removed, pickled in dilute sulphuric acid and finished.

Selection of Facings.—In choosing the facings for crowns or a bridge, or in fact for any form of partial denture, the greatest care should be used to select those of proper mold and shade. If it is impossible to get a facing to match exactly the shade of the natural teeth, it is better that it should be slightly darker rather than lighter than these. If a crown is the least bit too light in color it is conspicuous and is the first thing seen when the patient opens the mouth, while if it is but slightly darker than the neighboring teeth is not so noticeable.

In restoring the six anterior teeth, the facings should never be bought in sets as put up by the manufacturers. In the human mouth, these teeth are never all of the same shade. The central incisors have generally a yellowish cast. The laterals are of a bluish tint, especially at the incisal edge, while the canines are the yellowest teeth in the mouth anterior to the molars. If the facings restoring these teeth are all of one color, they will never present a natural appearance since their uniformity will at once advertise their artificial nature. They should be selected in pairs, the centrals, laterals and canines, each from a different set in accordance with the natural shading of these teeth.

As we go farther back in the mouth, we find the bicuspids have a tendency toward blueness again, while the molars are yellow. In selecting these teeth, the bicuspids, especially the first, should be matched as nearly as possible. With the molars there is not the same necessity of being so exact. They should be of the same general shade and may be darker than the natural teeth, but certainly not lighter.

The shape of the teeth should be studied carefully and the form of those lost should be reproduced as nearly as possible by their substitutes. A flat facing should never be used to restore a tooth which had a rounded face. The remaining natural teeth will here again serve as an index for the form of the selected facings.

Occlusion.—In addition to its other requirements, the articulation of a bridge piece must be as nearly perfect as it is possible to make it. This is a most important consideration and one to which there is, seemingly, very little attention given in this work. A bridge which is properly articulated will not only be more effective than one faulty in this regard but its use will be attended with less liability of loosening or injurng the abutments.

A large percentage of the cases of bridge-work are for the posterior part of the mouth and the dentist is most frequently called upon to restore lost molars and bicuspids. Where these teeth in either jaw, have been lost for any length of time their opponents in the opposite jaw are sure to have elongated to a greater or less extent (Fig. 745), and if no measure is undertaken to prevent, they will eventually be exfoliated. The normal line of occlusion must be restored in a case of this description, if a satisfactory denture is to be made to replace the lost teeth, whether it be a plate or a bridge. If a bridge is constructed without doing this, it can be never so serviceable to the patient as where the occlusion has been made normal. The triturating motion so necessary for the perfect performance of the masticatory function, is in-

terfered with or prevented altogether, the only movements possible being the opening and closing of the jaws in which the food may be pressed or crushed, but not ground. The moment the mandible is thrust the least bit forward, the jaws are thrown apart and the only point of contact is the distal cusp of the elongated molar, with the mesial cusp of the lower molar opposite. (Fig. 746.) Where this elongation of the teeth has taken place, the cusps must be ground away to the normal line of occlusion and the teeth carved so as to reproduce as

FIG. 745

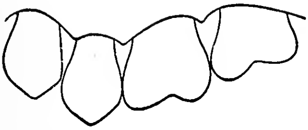
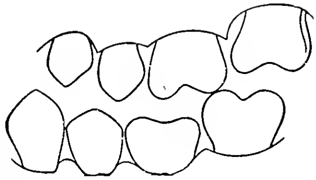


FIG. 746



nearly as possible the original cusps. If they have become very much elongated, it may be necessary to devitalize and crown them, or to restore their masticating surfaces by building up with gold.

BRIDGES WITH BREAKS IN THE CONTINUITY OF THEIR BODY.

Cases present which may exhibit conditions favorable for the employment of bridge-work, except that at some part of the arch there is a tooth which may be mechanically unnecessary in the support of a bridge, and which it is the part of wisdom to leave out of the bridge structure. It may be that the tooth has such a lack of parallelism between its axes and those of the abutments that its utilization is impracticable. The author of the only satisfactory device for application in such cases is Dr. J. L. Williams.[1]

FIG. 747

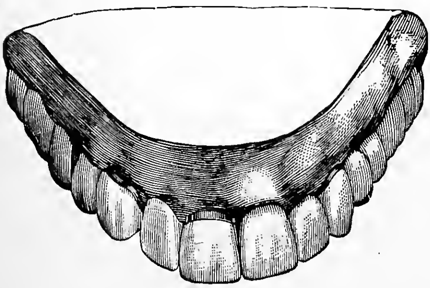
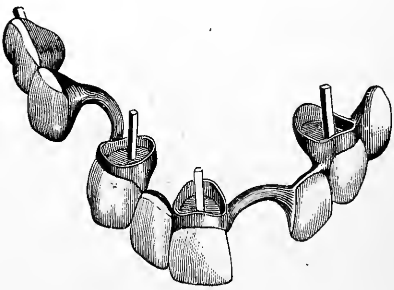


FIG. 748

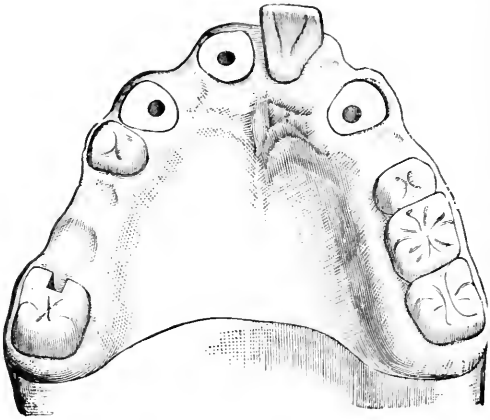


The connecting bars may be formed by annealing and slightly flattening bars of iridio-platinum wire No. 14; these are bent about the necks of the teeth, not quite touching them, their ends resting solidly against the stays of the dummies. A typical case is illustrated in Figs. 747–749. A modified form of the same device is seen in Fig. 750.

1 The Dental Cosmos, Vol. xxvii, p. 705.

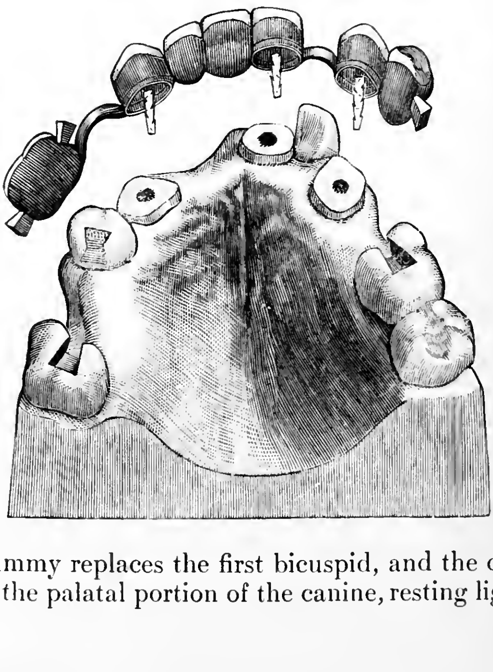
The device proves useful in such cases as the following: a crownless lateral with a good root; an unblemished canine; the first bicuspid ab-

FIG. 749



sent and the second bicuspid root fit to serve as an abutment. A bridge is constructed, the lateral and second bicuspid having abutment crowns

FIG. 750



adapted; a dummy replaces the first bicuspid, and the connecting bar passes around the palatal portion of the canine, resting lightly upon the gum.

EXTENSION BRIDGES.

The principle of construction of this variety of bridge-work is that of a portion of the body of a bridge extending beyond an abutment, and having attachment at but a single point. It will be seen that there is involved a faulty and, it may be, a vicious mechanical principle. It is a variety of structure which has no counterpart in bridges as the engineer knows them.

The danger attending or following its employment is mechanical displacement of the abutment itself, the danger being in the direct ratio of the amount of force received by and through the extension, and in the inverse ratio of the number and strength of the abutments.

A consensus of contemporary opinion places these devices in the category of abuses of bridge-work.

The mildest form of the above is seen in such a fixture as Fig. 752. Faulty though the design may be, it cannot be denied that there are cases in which the employment of the work is justifiable.

The force received upon such a fixture as Fig. 752 necessarily tends to rotate the abutment crown or even the root itself; the same objection obtains with any fixture supported by but one abutment. The details of construction of such a piece and of Fig. 751 are evident.

Fig. 751

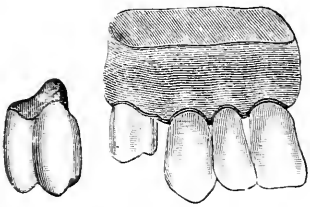


Fig. 752

Figs. 753–755 (after Dr. Parr) exhibit a case in which the extensive work figured has its justification in the advantages afforded by such a piece over a plate denture, so long as the abutments maintain their fixation. It is to be recognized that this, as in other extreme cases of bridge-work, is governed by matters of economy.

It is necessarily doubtful how long the abutments will persist in a condition of secure fixation, so that the question concerns the purse of the wearer: can he afford (financially) to pay the fee for such an appliance for the term of service it is likely to afford him?

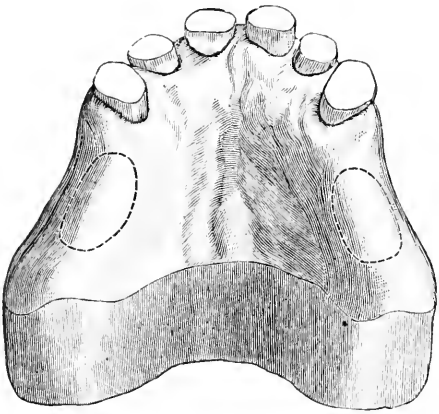
The proper construction and adaptation of such pieces tax to the utmost the skill, knowledge, and ingenuity of the expert mechanic; the novice is wise in avoiding them.

The figures illustrate the most extensive apparatus anchored to abutments which dental literature records. The crowns and dummies of such cases are constructed after the methods described. Oval plates of gold are swaged to cover a greater area of the ridge than embraced by the base of the teeth they are to support. Upon them plate teeth or all-gold crowns may be fitted, and attached to the terminal dummies.

REMOVABLE BRIDGES.

These are devices which are so attached to abutments that they may be removed by the operator for the purpose of repair or to gain access to abutments which might possibly require therapeutic aid; again, as a means of bridging spaces to which, owing to the position of the abutments, it would be impracticable to properly adapt fixed bridges. Others

Fig. 753



are designed and attached so that the patient may remove them for hygienic considerations.

The first consideration is the perfect protection of the abutments themselves against the entrance of fermentable material, otherwise the spaces existing between the abutment, crowns, and these bases them-

Fig. 754

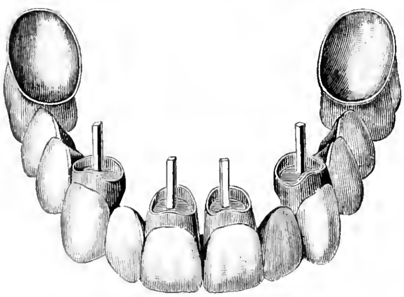
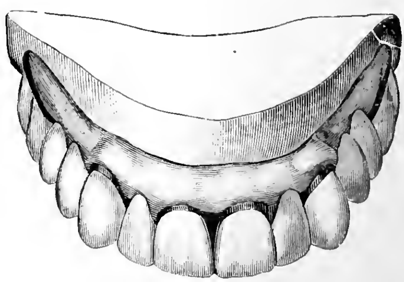


Fig. 755



selves would, by being accessible to the causes of dental caries, bring about the dissolution of the abutments.

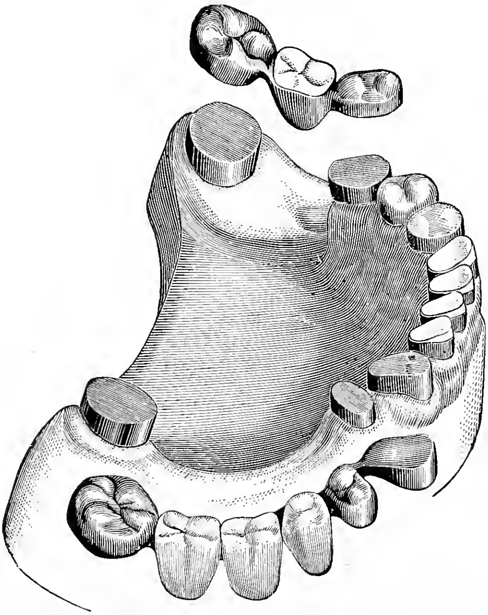
In devising this variety of bridge or in applying devices it is preferable to select those whose mode of retention and method of construction are simple.

The means of anchorage of this variety of bridge-work is either through telescoping barrels; posts fitting in sockets anchored in the

roots of teeth; attachment by means of screw sockets in prepared abutments; by variously shaped sockets in the body of the bridge or attached to the abutment crowns, in which closely-fitting posts are slipped. Their degrees of simplicity are in the order named.

With the advent of removable bridges, the possibilities of bridge work have been greatly increased. In many cases where it would be inexpedient to put a fixed bridge, a perfectly satisfactory and lasting removable bridge may be placed. This is true for instance of the lower jaw where all of the molars have been lost. These teeth may be restored by the use of removable extension saddles, a restitution not to be thought of by means of fixed bridge-work.

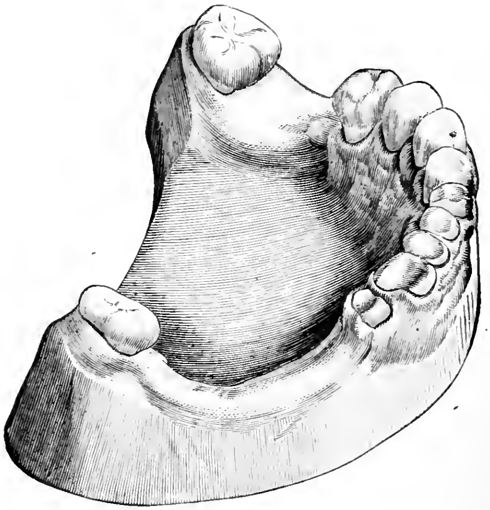
Fig. 756



Aside from the enlargement of the field of usefulness, there are many points of superiority of removable over fixed bridge-work and one of the most important of these, is its hygenic character. It is absolutely impossible to thoroughly cleanse and sterilize a bridge which is permanently fixed in the mouth. There will be portions of it which cannot be reached with the tooth-brush, and any antiseptic solution which would be strong enough to disinfect it perfectly would be injurious to the mucous membrane. In the case of a removable bridge, however, it may be taken from the mouth in a moment and sterilized by boiling, or cleansed by other approved means which the patient is capable of using. The inner abutments are then easy of access, and being perfectly smooth on all sides may be cleansed with very little trouble before the bridge is replaced.

Another point in favor of removable work, is the ease with which it may be repaired in case of accident. After many of the accidents which happen to a bridge, it is necessary to remove it in order to repair it, and if the piece be fixed, it will be more or less injured in its removal from the mouth and the removal itself will be a matter of considerable difficulty. In a large piece where there are several abutments, if one becomes loosened, in order to re-cement it, it would be necessary to cut and loosen all of the abutment pieces before the bridge could be removed. In many instances the abutment tooth would be entirely ruined before it was discovered that there was anything the matter with it because the seat of the difficulty is out of sight beneath the bridge. With a removable piece, if one of the abutment caps becomes

Fig. 757



loose, it will be instantly discovered and may be re-cemented at once without the slightest trouble or injury to the bridge.

Another and very important consideration is the facility with which any of the teeth adjacent to a removable bridge may be treated in case of accident, decay, or other pathological condition. The bridge may be taken out, the rubber dam put on over the abutments and there will be ample room for any operation without further separation.

The value of removable bridge-work depends entirely on the accuracy with which the various details of construction and adjustment are done. The fitting of the several portions of the bridge to the abutments must be as nearly perfect as possible or the work cannot be satisfactory.

The first of these devices was that of Dr. R. W. Starr[1] (Fig. 756.) The abutment teeth were trimmed to a form which permitted the adjustment of ferrules which were cemented to their bases.

[1] The Dental Cosmos Vol. xxviii, p. 18.

Telescoping barrels, with properly occluding caps, are fitted over these, being cut away at such aspects as would prevent their placement in a common piece. A dummy crown is fitted between and attached to them. The pieces were set with gutta-percha.

The same principle is applied in Figs. 760–762.

Fig. 758

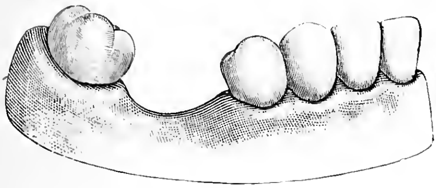
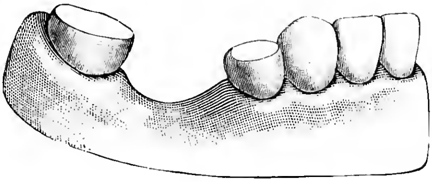


Fig. 759



The illustrations explain in themselves the methods and steps of the construction.

Another method of applying a removable bridge to simliar cases is that of Dr. R. B. Winder. Collars are fitted to the abutments, to which perfectly flat caps are soldered. A bite and impression are taken in which the caps are withdrawn. Occluding caps are formed, which are

Fi6. 760

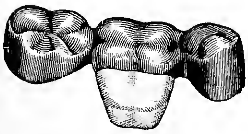
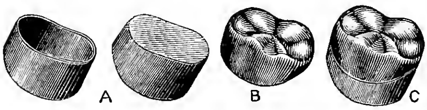
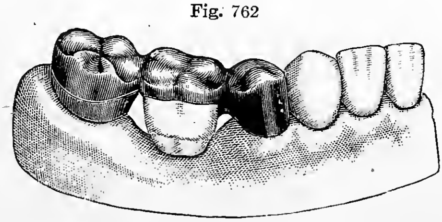


Fig. 761



filled flush with solder and ground flat to fit the ferrule tops. Dummies are constructed and united to one another. The caps are to be attached either by screws passing into the crowns of the abutments or else by nuts passing over screws which have been attached to the ferrule tops, over which the occluding cap is set, being perforated for the passage of the screws. It is advised that the pieces be now placed in position in

Fig. 762



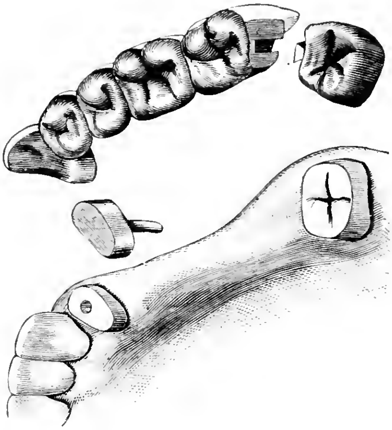
the mouth, held together by means of adhesive wax. Over the pieces sufficient investing material is placed to hold them together; they are then encased in investment and the caps attached to the dummy block.

Holes may be drilled through the deepest part of the cap large enough to admit the screws, and continued into the crowns as deep as

the screws are long. The holes in the crowns may be enlarged and the screws slightly oiled. Zinc phosphate is placed in the pits, the bridge is set in position, and the screws thrust in to the cement while the latter is still soft.

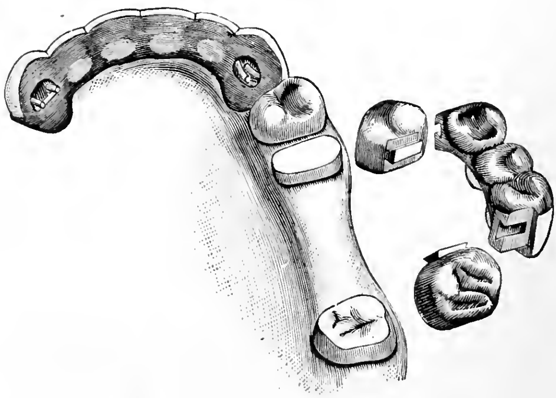
These forms of bridges are applicable where the abutment teeth

Fig. 763



incline toward one another at such an angle as to render the placing of complete cylinders impracticable or impossible. The more general employment of the same or similar methods in many of the cases which receive fixed bridges would remove many of the objections urged against the latter.

Fig. 764



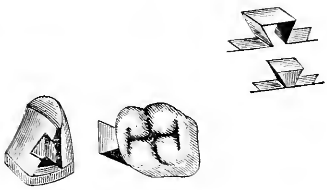
An applicable and well-devised appliance is shown in Fig. 763,[1] in which fixation of the bridge to the abutments is secured by means of a telescoping collar placed over a capped root, its other extremity having a socket fitted to and slipped over a retaining shoulder.

1 Dr. C. L. Alexander.

A bridge held by two similar shoulders, but removable outwardly, is shown in Fig. 791: it is designed to overcome the tendency to displacement by the stress of mastication present in those devices which are inserted vertically.

Dr. Parr's method of constructing these telescoping ends is by far the simplest offered. Two pieces of platinum plate are shaped as in Fig. 765, so that one shall telescope the other: the inner one is filled flush with wax and invested; the wax is removed, the space is filled by melting gold plate in it. The outer section is filled with investment and its walls are made rigid by flowing gold over them, or, what is preferable, adding thick pieces of plate to each side and joining them by means of 22-carat solder. The shoulders are soldered to the crowns, the slots are adjusted to the shoulders, their ends attached to the stays of the dummies. It is necessary that the slots should be immovably held against the stays to ensure their correct position in the finished piece. Soft adhesive wax is placed around them, attaching them to the backings, an unusually large amount of the wax being used. The piece is chilled and the dummies and sockets withdrawn. If both sockets come away without detachment, the piece is immediately invested; if one or both have broken away, the sharp line of fracture of the brittle cement furnishes the guide for their accurate replacement.

Fig. 765



The writer advises that the free ends of the shoulder-piece be left as extensions which are adapted to the wall of the abutment crown, the socket piece to have similar wings which shall outline the terminal wall of the bridge body in its finished state.

ABUTMENTS.

Of the different styles of abutments which may be utilized in removable bridge-work, the telescope crown is probably the one most frequently indicated. The telescope crown should not be confounded with the shell crown. The shell, or full gold crown simply covers the tooth or root and is used as a single crown, or as an abutment in fixed bridge-work. In the telescope crown, there are two caps, one telescoping and fitting the other as exactly as the tubes or slides of a telescope, the inner cap of which is cemented to the tooth serving as an abutment. This crown is only used in removable bridge-work. It is indicated for molars and bicuspids where a full gold crown can be used, but should never be employed in the front of the mouth. The tooth for the reception of a telescope crown should be prepared in exactly the same way as for a full gold crown, with the exception that a little more of the tooth structure should be ground away from the occlusal surface. The sides should be trimmed so that the tooth is very slightly conical,

its greatest circumference being about one sixteenth of an inch below the gum line.

It is not desirable that the abutments should be exactly parallel, but they should be very nearly so. Advantage should be taken of the natural inclination of the teeth. If they are diverging, they should be ground so that when the bridge is put in place, the teeth will be drawn together slightly and spring back as it is pressed home. If the teeth converge they will be forced a little apart. This slight natural spring of the teeth will assist in holding the bridge firmly in place, but it must be very slight, otherwise the removal and replacing of the bridge would have a tendency to loosen the roots.

The telescope crown should be made of coin gold, or some very hard alloy of that metal. The regular twenty-two carat plate as purchased at the dental depots is too soft to withstand the strain and wear to which it will be subjected. If the telescope crown be accurately made of a rigid material like coin gold, there will be practically no wear on it, even after years of use. The fluids of the mouth seem to form a coating

Fig. 766

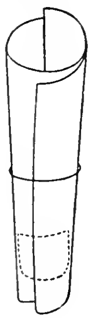


Fig. 767

which prevents the actual contact of the metal in the two caps, however closely they may fit, but if the material of which the bands are made be so soft as to allow of their stretching in the slightest degree, this would render the piece worthless in a comparatively short time.

The band of coin gold No. 30 gauge is made to conform to the tooth, the sides being nearly parallel, or slightly diverging toward the neck, and it is festooned to follow the gum line so that it will go an equal distance under the free margin all around. It is then cut off even with the top of the stump and filed perfectly flat and a floor of No. 28 coin gold is sweated to it. In sweating the floor to the band, the former is first flattened so that there will be close contact between it and the band all around. It is then fluxed and held by one corner in a pair of finely pointed pliers over a Bunsen flame until the parts are united. The surplus gold of the floor is then trimmed away and the sides of the cap polished. We now have what is practically a seamless crown and are ready to make the outer cap. As a first step, the inside of the cap is given a very thin coating of melted wax to prevent its union with the

fusible metal which is to be poured in it. It is then pushed into a paper tube, which can be made by rolling a piece of paper around a lead pencil or stick of suitable size, held together with a small gum elastic band, and the cap and the tube filled with fusible metal. (Fig. 766.) This renders the cap perfectly solid so that it is impossible to crush it. A new measurement is taken at about the middle of the cap and the gold for the outer band is cut a little shorter than the measurement and slightly tapering, so that the band will be a little larger toward the neck, and its ends sweated together.

It is festooned to follow the lower edge of the inner cap and forcibly driven over it to within about one-sixteenth of an inch of this edge. (Fig. 767.)

The band is then cut level with the floor of the inner cap and filed flush with it. It is then removed and a floor of No. 30 coin gold is sweated to it. The extending edges of the floor are then trimmed flush with the sides of the band and it is ready for the contour.

This is made by building it on the outside of the band. A piece of No. 28 coin gold is cut, its width being about the same as the width of the outer band and its length about twice the diameter of the cap.

FIG. 768

FIG. 769

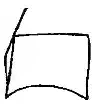


FIG. 770

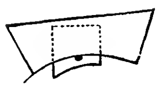


FIG. 771

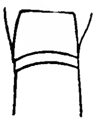


FIG. 772

(Fig. 768.) The lower edge of this is then bent slightly inward as it is desirable that the solder used should not unite the piece all the way up the band, but should catch it only at the extreme edge as in Fig. 769. The contour piece is then placed on the band, the lower edge coming only about one-thirty-second of an inch from the lower edge of the band, fluxed and soldered with a very small piece of 22-carat solder (Fig. 770), using the small blue point of the blowpipe-flame. It is then cleansed in acid and another piece attached to the opposite side in the same manner. These contour pieces are always attached to the mesial and distal sides of the cap. The cap with the wings attached is placed on the inner cap and the wings thrown out to the desired angle, as in Fig. 771, and the ends turned in at the buccal and lingual side so as to give a natural contour to the crown. (Fig. 772.) The crown is then well fluxed between the contour pieces and the band and along the edges of the wings and the whole soldered with 22-carat solder, partly filling the space between the wings and the band.

This is done by laying the crown on a charcoal block and placing the pieces of solder on the buccal and lingual sides between the ends of the two plates (Fig. 773), and drawing it down on each side with the small flame of the blowpipe. The surplus gold of the contour is then cut away and the contour filed flush with the floor of the cap. A suitable cusp is then made, and its under surface filed flat to fit the top of

the cap. The cusp and cap are then fluxed, wired together and soldered with 20-carat solder, laying the crown on its side on a charcoal block, the piece of solder on the band in contact with the cusp and soldering with the small flame of the blowpipe. (Fig. 774.)

Where the teeth are short or where there is to be but one retaining abutment, a combination of the telescope cap with a tube and split pin forms a most excellent attachment. The inner band is made as for the regular telescope crown. A hole is then made in its floor and a tube set in, resting on the floor of the pulp chamber and waxed firmly in place. (Fig. 775.) In adjusting the tube, care must be used to have its long

Fig. 773

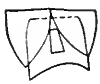


Fig. 774

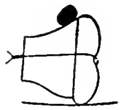
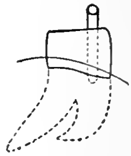


Fig. 775



axis exactly parallel with the sides of the band. The cap is then filled with investment and the tube soldered in place with 20-carat solder. The tube is now cut off flush with the floor of the cap and the cap polished. The inside of the cap is now coated very thinly with wax and it is filled with fusible metal as already described.

The outer band is made and contoured exactly the same as for a regular telescope crown and the top filed perfectly flat, and a floor of No. 30 coin gold sweated to it.

The position of the opening of the tube is ascertained by placing the outer cap in position on the inner cap and with a soft pine stick and hammer tapping the floor directly over the mouth of the tube.

Fig. 776

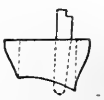


Fig. 777

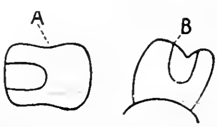


Fig. 778

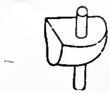
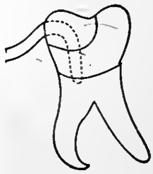


Fig. 779



When the outer cap is removed the outline of the hole will be clearly defined on the inner side of the floor and may be punched or drilled to the proper size for the reception of the pin. The split pin is then made to fit the tube easily but not loosely, but should fit the hole in the floor of the outer cap tightly and be fastened to it with hard wax while the parts are in position. The cap is then removed, filled with investment and the pin soldered to the floor with a very small piece of 22-carat solder. The surplus pin is cut away nearly to the floor of the cap. (Fig. 776.) The cusp is then selected, the under surface filed flat and a hole drilled through it to receive the part of the pin which projects

above the floor of the cap. They are then wired together and soldered in the same manner as the regular telescope crown. This attachment is especially useful in molars or bicuspids where the crowns are very short.

Another form of anchorage which has given great satisfaction is the inlay attachment. In this style of abutment the natural crown of the tooth is preserved and it is especially applicable to molars. The tooth is devitalized and cut out on the occlusal surface from one-third to one-half the length of the crown, and down on the mesial side far enough to allow for a heavy round bar, about No. 13 gauge and a sufficient thickness of gold to give stability to the inlay. (Fig. 777, A and B.) The pulp chamber is then filled with gutta-percha, the cavity being made non-retentive, leaving the sides curved or straight and the bottom rounded or flat as the operator desires. Pure gold of No. 34 or No. 36 gauge, or inlay platinum is then burnished into it as for an inlay, great care being used to have the margins perfect.

A hole is then made near the distal end of the matrix and through the gutta percha to the floor of the pulp chamber and in it is placed an iridio-platinum tube, large enough to take a pin of No. 13 or 14 gauge.

Fig. 780

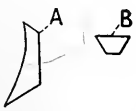
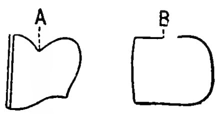


Fig. 781

Fig. 782



It is then waxed in place and the wax packed tightly in the matrix and around the tube. It is now removed, invested and filled with coin or pure gold, thus making a perfect inlay with a tube extending through it. (Fig. 778.) A groove is now cut from the tube to the mesial end of the inlay with small round-edged carborundum wheels or fissure burs and finished with plug finishing burs, of the same size or slightly larger than the inside diameter of the tube.

The bar and pin are made of platinized gold wire left open for about one-quarter of an inch from the end and bent so that it will go to the bottom of the tube and lie closely in the bottom of the groove. Fig. 779 shows a section of the tooth with the inlay and tube in position and the bar and pin in place.

The articulation is taken in plaster with the inlay in position in the tooth, the cast prepared and the bridge made, the bar being soldered firmly to it.

Another style of abutment, especially adapted to bicuspids and molars having long crowns, is the dovetailed key and shoe attachment.

The key is made of iridio-platinum and filed smooth to form a dovetail as in Fig. 780, A and B. A strip of the same metal No. 32 gauge is bent to fit the sides of the key perfectly and filed off even with the face or broad side of the key, and a floor of the same metal fitted to it and soldered with a little pure gold. (Fig. 781, A and B.)

In using this form of abutment the side of the crown to which the key is to be attached should be straight from the gum line to the top of the cusp, and should be reinforced with a piece of No. 28 gauge coin gold soldered across the whole face of the crown. (Fig. 782, A and B.)

The key is then put in place, a hole drilled through it and the side of the band, and it is fastened with a small platinum rivet, such as a tooth pin, the under surface of the key having first been covered with pure

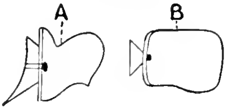


Fig. 783

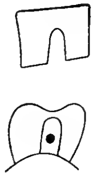


Fig. 784

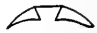


Fig. 785

gold, as the union between iridio-platinum and the solder is not strong. It is then soldered to the cap, using very little solder. (Fig. 783, A and B.) The female part of the attachment, or shoe, is then slipped over the key and a thin piece of platinum cut out to slip down over the key next to the crown and this is burnished closely to it. (Fig. 784.) It is then waxed to the shoe, removed, invested, and covered with pure or coin gold (Fig. 785), after which it is trimmed to its proper dimensions, re-

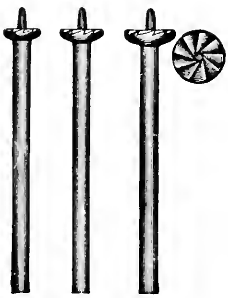


Fig. 786

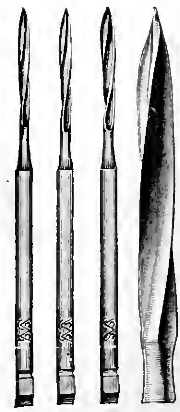


Fig. 787

placed on the crown, the facings ground in, and the bridge constructed. If a saddle is to be used, it is first waxed carefully to the shoe, removed and soldered, after which it is replaced on the model and the bridge constructed as before.

For attachments for any of the anterior teeth or for bicuspids, where the teeth are to be cut to or below the gum line, the cap with the tube and split pin will be found to be most generally useful.

The tooth is cut down, the band made and fitted in the same way as

for a Richmond crown, being carried about one-sixteenth of an inch under the gum, after which it is removed and the root cut down just below the gum line on the labial side, but not so low as for a Richmond crown, and leaving it high on the palatal or lingual side. For doing this, the Ottolengui root facers (Fig. 786), are best adapted as they will take the root down quickly and evenly and with less mutilation of the gum tissue and consequently less pain to the patient.

The band is then cut flush with the top of the stump and the floor sweated or soldered to it.

In enlarging the canal of a root to receive either a pin or tube, spear pointed drills or instruments which cut on the end should never be used, as there is danger of perforating the side of the root.

The canal is first opened with broaches, these are followed by Gates-Glidden drills, beginning with the small and working up to the large ones and enlarging the canal to within about one-eighth of an inch of the apex. These are followed by the reamers which are made in sizes to correspond to the size of the tubes or pins which are to be used. (Fig. 787.) Both these and the Gates-Glidden drills have smooth

FIG. 788

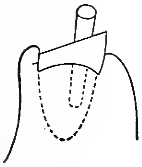


FIG. 789

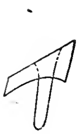


FIG. 790

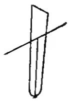


FIG. 791

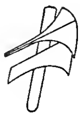
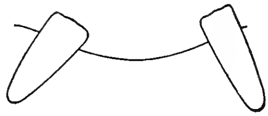


FIG. 792



guide points which will follow a canal, but will not cut on the end and there is very little danger of perforating a root in using them.

The canal having been enlarged to the proper size, a hole is made in the floor of the cap which is placed on the root, the tube adjusted and waxed to it with sticky wax. (Fig. 788.) It is then removed with the cap, invested and soldered the same as a pin in a Richmond crown.

After it is soldered, the tube is cut off flush with the floor of the cap and the cap polished, care being used not to round the corners (Fig. 789.)

The cap is then placed on the root and the impression taken and cast made. The subsequent steps are done on the cast.

The floor of the outer cap is made of No. 28 coin gold, a hole being drilled through a piece of proper size for the case so that the pin, which has been previously fitted to the tube, will fit tightly. They are then placed in position on the inner cap, waxed together, removed and soldered with a very small piece of 22-carat solder. (Fig. 790.) The pin and floor are then cleansed in acid, replaced on the inner cap and the floor trimmed flush with it all round.

A half band is of No. 28 coin gold and should extend about half way to the buccal side of the floor as in (Fig. 791.) It should extend only to the gum line on the lingual side and should not go below it. It is

then waxed to the outer floor, removed and soldered, using a very little 22-carat solder.

Another way of making a tube and split pin attachment which is especially useful in cases where the roots stand at such an angle that it is not possible to insert the tubes to a sufficient depth and have them parallel, is to have the split pin attached to the lower or inner cap and the tube imbedded in the bridge. Take for example two canine roots in the lower jaw, standing as represented in Fig. 792.

In a case of this description, the roots are prepared in the same way as when they stand in a normal position, with the exception that the mesial or approximal angle is cut away, in order that the bands may be

Fig. 793

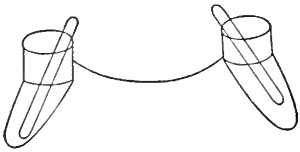


Fig. 794

adjusted with their sides nearly parallel to each other. The bands are then fitted, the roots cut down, the canals enlarged to receive a strong pin and a plaster impression taken with the bands and pins in position as in Fig. 793. A cast is then made, the bands cut flush with the top of the stump and the floor of No. 28 gauge coin gold is sweated to them. An opening is then made through the floor to fit the pins tightly and the pins are bent just beneath the floor so that when they pass through they will be parallel with each other or nearly so. (Fig. 794.) They are then waxed together invested and soldered from the under side.

In making the outer cap the floor of No. 28 gauge coin gold is drilled so as to fit the pin easily but not loosely. It is then cut flush with the sides

Fig. 795

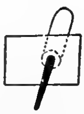
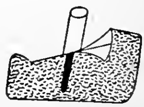


Fig. 796



of the inner cap and the half band made and soldered to it, after which it is replaced on the inner cap. The tube is next placed over the pin and is made to set down closely on the floor all around and is waxed to it with hard tough wax. It is then removed, a little investing material carried into the tube and a small iron wire inserted, letting it extend about one quarter of an inch below the floor. (Fig. 795.) This will hold the tube in position and is imbedded in the investment, the tube being soldered to the floor with 22-carat solder. (Fig. 796.) The facing is then ground to the floor of this cap and when the bridge is invested for soldering, a small iron wire is inserted in the investment to prevent the tube from shifting, the same as when attaching it to the floor.

The abutments which have been described are all known as retaining abutments. By retaining abutment is meant one which holds the bridge firmly in place in the mouth, preventing its shifting or dropping out, such as a telescope cap, tube and split pin, etc.

A supporting abutment is one which supports one end of a bridge, but has nothing to do with retaining the piece in the mouth. A countersunk gold filling in which a spur rests is an example of this latter style.

Countersunk Supporting Abutments.—A hooked spur resting in a counter sunk gold filling forms a most excellent support for one end of a bridge. This is especially the case in the lower jaw, where it will safely support a bridge of two or three, or even more teeth with but one

Fig. 797

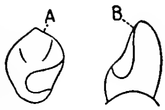
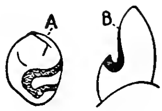


Fig. 798

Fig. 799



retaining abutment. In the upper jaw, with a crown carrying a single dummy, the other end may be supported by the counter sunk filling, and it is often useful in furnishing additional support for a larger bridge with more than one retaining abutment.

Where a spur is to rest in a filling in any of the anterior teeth either upper or lower, the cavity is made in the palatal or lingual side of the tooth toward the bridge as in Fig. 797, A and B. Where the bite does not interfere the cavity is made at the basilar ridge where the enamel is very thick, and should be of good size, approximately about one-eighth of an inch in diameter. It is best to start it with a small carborundum wheel, using plenty of water, and cut through the enamel

Fig. 800

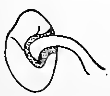


Fig. 801

Fig. 802

and give the general outline to the cavity before putting on the rubber dam. The rubber dam having been adjusted, the cavity is deepened with burs as much as possible without endangering the pulp. The cavity is well undercut and a filling of hard gold thoroughly condensed is inserted. It is made large enough so that the contour of the tooth is somewhat exaggerated as in Fig. 798. The filling is then polished and a hole drilled in the centre of it on the palatal side to within a short distance of the bottom of the cavity, the base of the hole being shaped with a bud shaped bur about the size of No. 14 to 16 gauge wire. A groove the same size is then cut from this opening to the distal side of the filling, being careful to leave a strong body of gold underneath so as not to weaken the filling. (Fig. 799) A and B.

The spur is made of iridio-platinum or platinized gold wire of No. 14 to 16 gauge, the size depending upon the size of the bridge and the amount of strain to which it will be subjected. The end of the wire is bent at right angles and pointed, leaving it just long enough to rest on the bottom of the hole with the shank resting in the bottom of the groove (Fig. 800), and passing under the cusp of the dummy or to the backing of the facing, should it be one of the six anterior teeth.

In the molars or bicuspids, the cavity is made in the crown of the tooth, extending down on the approximal side far enough to allow for the filling and spur. (Fig. 801.) The inside base of the cavity should be made, as far as possible, flat or slightly convex as in (Fig. 802.) This will make a firm base for the filling and there is little likelihood of the tooth being fractured or split by any pressure that may be brought to bear on it, the shape of the filling having a tendency to bind the crown together and prevent fracturing.

If the cavity is prepared so that the filling is wedge-shaped, there is a chance of its splitting the tooth, especially the bicuspids which are not strong on this line.

TUBES AND SPLIT PINS.

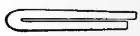
The tubes for removable bridge-work are made from iridio-platinum plate, No. 32 gauge. A series of polished steel mandrels of different sizes, ranging from about No. 13 to No. 15 Browne and Sharpe's gauge are used.

The size of the tooth must govern the size of the tube to be used, the smaller size for teeth having small roots and the larger size for the teeth with heavier roots. A strip of No. 32 iridio-platinum plate is beveled at the end to a knife edge; the edge is then turned slightly and rolled around the mandrel which should be one size smaller than the one which is to be used in finishing the tube. (Fig. 803.) The mandrel is then

Fig. 803

Fig. 804

Fig. 805



removed and the tube soldered with pure gold. The next size larger mandrel is then driven through the tube, stretching it and making it perfectly smooth and straight on the inside. The surplus plate is now cut away and the lap joint filed even with the rest of the tube.

A floor of the same metal is then soldered to one end of the tube with pure gold and the surplus trimmed away and the end finished with a file.

Split Pins.—In making the split pins for removable work half-round platinized gold wire is used. A piece of such length, that when doubled it will be about one-eighth of an inch longer than the tube, is bent at the centre and the two flat sides brought together and soldered just at the ends with coin or pure gold. (Fig. 804.) This end is then grasped

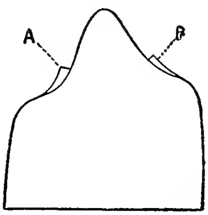
in a pin vise and the pin filed to fit the tube. If it is a very long pin it is left closed at the end, and to tighten it a very thin instrument is introduced between the halves, spreading them slightly, thus making a long, slender elliptic spring. (Fig. 805.) If it is to be a short pin, the closed end is cut off with a file so that the fit of the pin to the tube may be tightened by separating the ends of the former with a knife. In a split pin made in this way, there is no loss of material and the maximum strength of the metal is maintained.

SADDLE BRIDGES.

The most difficult piece of work which the crown and bridge specialist may be called upon to do, is to make a satisfactory extension saddle bridge for the lower jaw restoring the lost molars.

The success of a bridge of this kind depends entirely upon the perfect adaptation of the saddle to the ridge. In getting the impression for the saddle, it is a good plan to first take an impression in modelling composition and after enlarging it a little so that it will set further down on the ridge, to use it as a tray for taking the plaster impression. A good impression having been secured, the cast is prepared and should be of sufficient depth that there will be no chance of the die springing or breaking when swaging the saddle. The outline of the saddle is then marked on the cast and the cast built up a little with wax around theoutline as in Fig. 806, A and B, so as to turn the edge of the saddle and present a thick rounded edge to the soft tissues. The die and counter-die may be made of zinc and lead or of fusible metal, the latter being preferable because of its lack of contraction.

Fig. 806



The saddle is struck up of soft platinum of No. 30 or No. 32 gauge and should be just large enough to allow for the edge being

Fig 807

Fig. 808

Fig. 809

turned up all around. (Fig. 807.) It is then cleansed in acid, the under side painted with whiting to keep the gold from running over it, and coin gold flowed over the sides so as to fill them even with the turned up edges of the plate. (Fig. 808.) It is then swaged again with the die and counter-die, cleansed in acid and is ready for adjustment. The teeth which are to serve as abutments having been prepared, the inner caps are made and placed in position. The next step is the one upon which the success of this form of denture entirely depends, and that is the one of adjusting the saddle accurately to the alveolar ridge.

The Adjustment of the Saddle to the Ridge.—It will be found when the saddle is placed in the mouth that it is resting on the top of the ridge and has no bearing anywhere else. (Fig. 809.)

If this is not remedied, absorption will rapidly take place, allowing the piece to sag and bringing the whole strain on the abutments, with the result that sooner or later the roots will become loosened and lost. The saddle is placed in the mouth with the forefinger of each hand resting on the sides of the saddle, Fig. 809, and rocked from side to side. This will give an idea as to the amount of correction needed. It is then removed and grasped with the thumbs and forefingers and the sides bent together a little, then replaced in the mouth and tried again. This is repeated until the saddle rests perfectly solidly without rocking at all and sets comfortably on the ridge.

When it is satisfactorily adjusted it is held in place with the thumb and forefinger and it and the abutments covered thickly with plaster, covering the finger as well, and the saddle held firmly in position until the plaster hardens. It is then removed together with the inner caps

Fig. 810

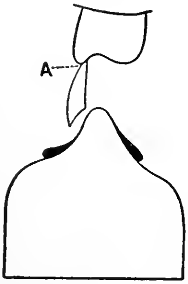


Fig. 811

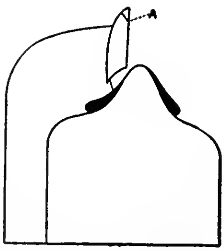


Fig. 812

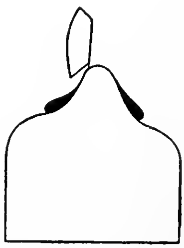
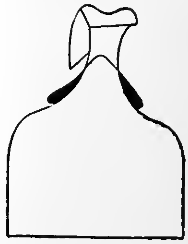


Fig. 813



and all are replaced in the impression, waxed in position, also waxing the inside of the caps, and a small cast run.

The inner caps are then removed with warm pliers and the outer or telescope caps are made, after which the parts are replaced on the cast and the saddle waxed to the outer caps. The whole is then removed, the inner caps taken away and the piece invested and the caps and saddle united with 21-or 22-carat solder. After cleansing in acid, the caps and saddle are placed in the proper position in the mouth and the articulation taken. This can be in plaster, modelling composition or wax, as it will be attached to the caps and the saddle and will come away with them so that there will be no danger of distorting the articulation by pressing it back in position on the cast. The cast is then prepared and the bridge constructed.

In constructing a saddle bridge it is better that the facings should not be ground to fit the saddle exactly, but should stand away from it for a little distance, (Fig. 810), the object of which will be seen later. The tips of the facings should be high enough to touch the lingual side of the buccal cusps of the upper molars as in Fig. 810, A.

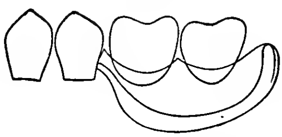
After the facings have been ground they are held in place with wax

and a wall of plaster built up on the buccal side so as to retain them in position after the wax has been removed. (Fig. 811.) The facings are then removed and the occlusal ends ground off at an angle of about forty-five degrees with the backs or lingual side as in Fig. 811, A, leaving them so that they will clear the occluding teeth by about a thirty-second of an inch. The facings are then backed with thin platinum, the backings touching each other and extending from the beginning of the bevel at the occlusal end to the saddle, which they should touch closely all along. (Fig. 812.) The facings are then waxed firmly to the saddle with hard adhesive wax, the wax being high enough to support and hold the cusps. (Fig. 813.) A solid cusp must be used, the buccal side ground or filed to fit the bevel of the facing and waxed in place.

The buccal and lingual sides are next covered with wax, the pink paraffin and wax being preferable as it is not sticky and carves nicely. Both sides are then carved to represent the natural gums. This should be done very carefully and the wax made perfectly smooth in order to secure a clean die, so that when the plates are struck up, they will require no finishing other than with pumice and rouge.

On the buccal side it should be carried above the lower edge of the facings and well up between them, as in Fig. 814. The carving on the lingual side should correspond in depth and breadth to the facings on the buccal side.

Fig. 814

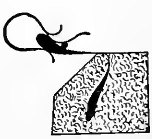


An impression is then taken of each side separately, carrying the plaster well above the gum line and over the heel on the buccal side, and on the lingual side, well above the cusps and below the saddle and far enough over the heel to meet the impression from the buccal side. (Fig. 815.) The impression should be deep enough to serve as a model from which to get good strong dies.

Fig. 815

Fig. 816

Fig. 817



The dies and counter-dies made, the buccal plate is struck up from No. 30 gauge coin gold and festooned carefully to fit around the facings. The lingual plate is struck from No. 28 gauge coin gold and fitted carefully, the part going over the heel being brought in contact with that from the buccal side. After they have been cleansed in acid the buccal plate is placed in position and held with small iron wire clamps, as in Fig. 816. The saddle is then held over a small alcohol flame for a moment

to loosen the wax from the plate and the teeth and wax removed and laid carefully aside. The saddle is then invested, lingual side down, only just enough of the investment being used to keep it from springing. (Fig. 817.) The investment is thoroughly dried out, the piece well fluxed and some pieces of 18-carat solder dropped in between the saddle and the plate. It is then well heated up and when it has rached a red heat, the blowpipe-flame is thrown on the under side of the saddle next to the investment and the solder drawn through all around. After it has been allowed to cool, it is cleansed in acid, and the saddle warmed slightly and the teeth pressed back into place until the fitting of the lingual plate show that they are in their correct position. The bridge is now ready for the final soldering.

The piece is invested, buccal side down, the investment on the occlusal side covering about two-thirds of the cusps and the saddle, to within about one-eighth of an inch of the lingual edge. (Fig. 818, A and B.)

After the investment has hardened it is warmed a little and the wax lifted out. It is then thoroughly heated up to a light red heat, fluxed and soldered between the cusps with 20-carat solder, the backings being united and connected with the saddle with the same solder,

Fig. 818

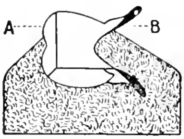


Fig. 819

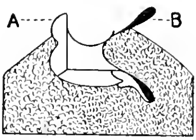
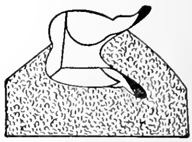


Fig. 820



enough being used to give sufficient strength and support to the bridge. (Fig. 819.) Some 18-carat solder is then melted over the lingual side of the saddle and cusps at A and B, Fig. 819 and the lingual plate carefully put in place, having been previously fluxed on the inner side. The whole investment is then thoroughly heated to a bright red heat and the flame of the blowpipe passed along the under side of the saddle and the exposed portion of the cusps (Fig. 820), until the solder has been drawn through and united the lingual plate all around.

The greatest care must be exercised in putting on this plate, as it has to be heated so very hot that it is easily burned.

After it has cooled it is removed from the investment, boiled in dilute sulphuric acid, washed and then dipped in alcohol and thoroughly dried. The points of the buccal plate which have been carried up between the facings are now bent outward and the space between the plate and the saddle and under the facings is filled with oxyphosphate of zinc. While the cement is yet soft, the points of the plate are pressed back again between the facings. After it has hardened, the cement is cleaned out from between the teeth and plastic gold packed in and over the points of the plate. The bridge is then ready to articulate and finish.

CEMENTING OF REMOVABLE BRIDGES.

In cementing a removable bridge, the inner caps are placed in position in the outer caps and wax flowed over the joints to prevent any of the cement from working in between them. The bridge is then cemented in the mouth in the same way as though it were a fixed piece. It is better to leave it in the mouth for several hours before attempting to remove it, so as to give time for the cement to get perfectly set and hard. It can then be taken out and the excess of cement removed from under the gums and around the teeth. A little campho-phenique wiped around the teeth and on the gums will relieve the soreness caused by the instrument.

COMBINATIONS OF THE PRINCIPLES OF PLATE- WITH THOSE OF BRIDGE-WORK.

The principle involved in this class of mechanism was utilized early in the present century as a means of retention for partial dentures. There is a combination of the support represented in the bearing of a plate upon the alveolar ridge, together with the rigidity secured by having terminals or extensions from the plate anchored in the roots of teeth or embracing them as closed and rigid cylinders.

The principle of anchorage in the roots of a natural tooth is that of embracing the natural teeth by closed cylinders; a combination of the two means of retention.

These devices posses certain advantages over clasp plates, in that there is no elasticity of the retaining cylinders: they slip over the abutments prepared for their reception, and being closely adapted to them, there is a greater rigidity of the dentures than with the ordinary clasp.

For their employment it is obviously necessary that the abutments should have sides which are parallel and the axes of both mutually parallel. They are usually designed for application in cases where the natural teeth are in such positions and have forms which would fit them to serve as bridge abutments, but the contour of the gum is such that it is necessary to employ gum teeth (Fig. 821.) They are, to all intents and purposes, removable bridges, having a greatly multiplied support from the natural gum.

It was stated in describing the bulkhead bridge, that should the contour of the gum be lost to such an extent as to preclude the application of a bridge, owing to the impossibility of correctly adapting plain teeth, a removable plate bridge might be employed. A removable bridge may be adapted to such a case as follows:

The canines roots are properly trimmed and capped. Removable crowns are fitted to them. A gold plate is swaged to fit the gum between the teeth, extending high enough on its labial aspect to furnish adequate support to the artificial gums, and the palatal edges far enough to furnish adequate support to the stays of the teeth. The plate is to be

made of two layers—that next the natural gum of No. 32 pure gold, and covered by a plate of No. 32 platinous gold: the two are accurately adapted to one another and united by means of 20-carat solder. The ends are to be accurately adapted to the abutment crowns. Plate and crowns are set in position in the mouth, and a wax-bite taken: this is removed and set aside. While the pieces are in position an impression of modelling composition is taken. Modelling composition is preferred

FIG. 821

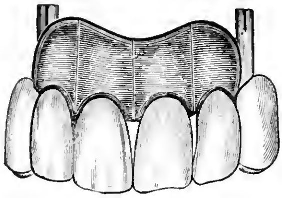
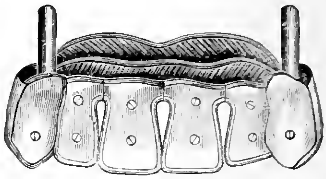
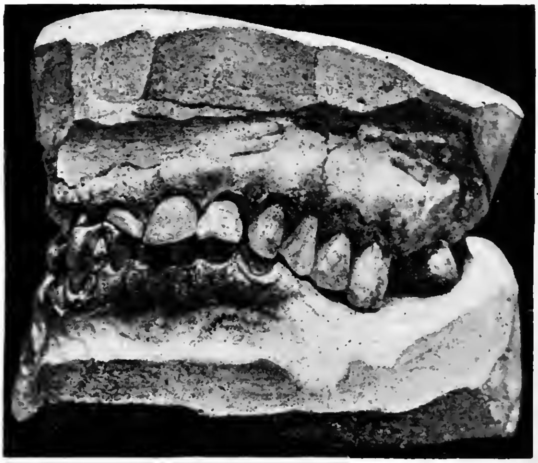


FIG. 822



to plaster, because the pressure upon the plate forces the latter into accurate contact with the soft tissues. Should plaster be employed, a ridge of softened wax, wide enough to fit between the abutments, is set in the impression tray, and over it the plaster. Now, when the impression is taken the plate is pressed up by the wax sufficiently to ensure that the natural gum shall furnish support to the finished bridge. A

FIG. 823



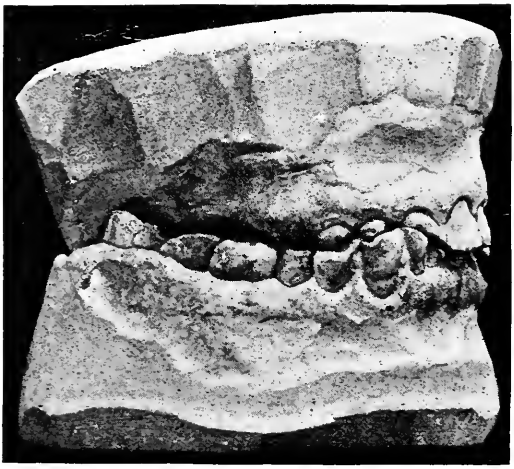
View of left side of the mouth, showing bicuspids and molars in contact with the ridge of the lower jaw.

cast is made and an articulation mounted. Should the plate be exposed by the movements of the lips, it may be necessary to adapt gum teeth (Fig. 821); if not, plain teeth are fitted; the gum is to be subsequently formed of pink vulcanite. The teeth are to have stays fitted. The abutment crowns are removed from the cast, and they, the teeth and the plate, boiled in acid. They are returned to the cast and joined to-

gether by means of adhesive wax: a wire laid across the backs from one abutment crown to the other, and covered by adhesive wax, holds them in position. They are invested, and when the investment is set, pieces of triangular wire are placed at the junction of the plate with the abutment crowns, and the pieces are attached to one another by means of 20-carat solder. If plain teeth have been employed, and contouring is indicated, a vulcanite gum is attached to the plate.

Figs. 823 and 824 show a remarkably distorted occlusion produced primarily by the loss of the left lower bicuspids and molars, and the right upper second bicuspid and molars, and the wearing away of the anterior teeth. It will be observed that the left upper bicuspids and molars and the right lower bicuspids and molars are in contact with the gums on the tops of the respective ridges, this condition being

Fig. 824



View of right side of the mouth, showing lower molars and bicuspids in contact with the ridge of the upper jaw.

caused by the shortening of the bite incident to the attrition of the anterior upper and lower teeth. The treatment of this case consisted in the construction of upper and lower partial dentures which embraced the principles involved in the combination of the ordinary removable plate with those of removable bridge-work. The procedure was as follows: the upper and lower anterior teeth, several of which were worn nearly to the gum-margin, were devitalized, cut down to uniform length and form, and provided with caps and hollow posts, over which telescoping caps with solid posts were accurately fitted, similar to that of the Richmond removable crown. The plates which were to unite the caps having the solid posts and to cover the alveolar ridge where bicuspids and molars had been lost, were constructed in two laminæ, the first of 22-carat gold of No. 29 gauge and the second of platinous gold of No. 26. The finer gold admits of more accurate adaptation to the plaster cast while the platinous gold affords the desired strength; the two were

united with solder, as is usual in the construction of lower plates. The caps with the hollow posts were cemented to place, the telescoping caps with the solid posts and the plate were placed in position, care having been taken to maintain the correct relation of one to the other, and an impression was taken in plaster as previously described. In removing

Fig. 825

the impression it is desirable that the plate and caps should come away with it. A model is then cast of sand and plaster which held the plate and caps in proper relation until they were united by solder, after which the succeeding details of construction were the same as in ordinary plate-work.

Fig. 826

The completed dentures are shown in the illustrations (Figs. 825 and 826.) The bite was opened sufficiently to restore normal relations. All of the remaining natural teeth were perfectly firm and gave promise of a long period of usefulness.

THE USE OF PORCELAIN CROWNS IN BRIDGE-WORK.

With the advent of the casting process came the more general use of all porcelain crowns for bridge-work in place of the veneers which had heretofore been used to partially hide the mass of gold which the bridge proper was constructed, thus producing much more artistic effects than was possible by the old method.

Any of the crowns of the different manufacturers which come nearest in mold, shade, and texture to the requirements of the case can be used. There must be sufficient depth of the bite to allow of every crown having a base deep enough to give strength and stability to the bridge.

These bases are preferably cast, although it is possible for one possessing the necessary skill to make them by swaging and soldering.

The greatest difficulty with which we have to contend in making these bases is due to the contraction of the cast metal on cooling. The result is that the crowns do not fit as they should and there is more or less cutting, trimming, and fitting to do, before they will go in place, and not infrequently it is necessary to do the work over again and perhaps not even then will the desired result be attained.

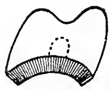
The method has been tried of first burnishing or swaging pure gold over the bases of the crowns and then waxing up and casting over the pure gold. This has perhaps improved matters somewhat, but still it is very rarely that it has been possible to secure anything like a perfectly fitting base, especially if the crowns are of any considerable size, for with the larger castings there is a proportionately greater amount of shrinkage.

In 1911, Frank W. Peeso conceived the idea of building out, or enlarging, the base of the crown before waxing, in order to make up for the shrinkage of the gold, and he hit upon a plan, the carrying out of which, while not entirely overcoming the difficulty in every instance, which is probably due to faulty technique, has, in the majority of cases, reduced the trouble to a minimum.

This method does not do away with the shrinkage of the gold, for that is an inherent property, which nothing can overcome, but by it we counteract or make allowance for this contraction of the metal on cooling.

The method of procedure is first to swage or burnish tin foil, of varying thicknesses according to the size of the crown, over the base, in reality making a base of the metal, as in Fig. 827. It is then lubricated and the wax base is built over the tin foil, the lubricated surface allowing its easy removal. The size of the base of the crown has, of course, been increased the amount of the thickness of the tin. We have thus made allowance for the shrinkage, so that when the crown is placed in the casting it fits very closely, and if we have been very careful in our technique, there will be little or no trimming to be done.

Fig. 827



The thickness of the tin foil varies according to the size of the crown, the largest, of course, requiring the heaviest foil. Three sizes are used, the first being about .005, the second .007, and the third .009 of an inch in thickness.

The burnishing of the foil over the bases is very quickly and easily done. The lighter foil can be pressed nearly to place with a piece of soft rubber and the wrinkles at the edges smoothed out with the thumbnail or a piece of orange wood. With the heavier foils a piece of orangewood and a small burnisher are all that is required to secure the close adaptation which is necessary to insure a perfectly fitting base.

In making the bases for a series of crowns for a bridge, it is not advisable to cast them together in one piece, as if the bridge is of any considerable length, the shrinkage would be proportionately great in that direction, so that it would be necessary to grind the crowns on their

approximal surfaces, before they would go into position on their bases. This would result in shortening of the bridge and leaving a space between it and the adjoining teeth or abutments. The best way is to cast these bases separately, and in no instance should more than two be cast together. The casting of each base separately and afterward uniting them does away with the shrinkage which would otherwise take place.

The casting of the bases for abutment crowns may be done directly on the caps, or they may be cast separately and afterward soldered to the caps. The latter way is preferable in removable work as there is less danger of disturbing the accuracy of adjustment between the outer and the inner caps.

The same method of procedure obtains where a saddle is used as an additional support to the abutments and the crowns mounted on this saddle. If there is no great depth between the occluding teeth and the saddles, the crowns are ground so as to leave sufficient space for the base. (Fig. 828.) The crowns are tinned in the manner described and the wax flowed between the bases and the saddle which has previously been lubricated. They are then carved and removed from the crowns and saddles separately, the sprue wire attached to the lingual side and the bases cast.

They are afterward adjusted in position on the saddle and invested, each piece being held in place by a little wire clamp, the wire passing

Fig. 828

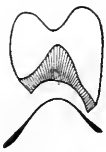


Fig. 829

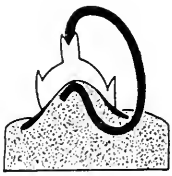


Fig. 830

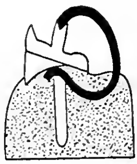


Fig. 831

from the top of the post to the under part of the saddle directly beneath. (Fig. 829.) With the half cap, the clamp extends from the top of the post to the under side of the floor. (Fig. 830.)

The investment should be very light and just fill the under side of the cap or saddle, leaving the whole of the upper parts exposed. This facilitates the thorough heating up of the piece and the solder is easily drawn through from the lingual side, uniting the bases to the saddle and to each other. The crown side of the bases should be well coated with whiting or some antiflux, so that there will be no danger of the solder flowing over this surface and destroying the fit of the crowns.

Saddles.—The saddles are struck up of 32 gauge soft platinum plate and are afterward heavily reinforced by flowing coin gold over the outer surface, after which they are adjusted in the mouth and their relation to the abutments obtained by taking an impression over the abutments and saddle, while the saddle is pressed firmly into the tissues.

Deep Saddle.—Where there has been a considerable amount of resorption and there is a great depth between the occluding teeth and the

ridge, it would make these pieces unnecessarily and undesirably heavy to build solid bases extending from the crowns to the saddle. This will apply where there is to be an abutment at each end of the bridge and also in extension saddles which are anchored only at one end, as in the lower jaw where the molars are missing. The lower edges of the crowns are beveled so that the bases may come up over the gingival edge, gripping them tightly, thus affording a firm seat and minimizing the possibility of fracture.

The bases may be made in the form of a ring, covering the beveled edge and extending just far enough underneath to form a positive seat for the crown, as in Fig. 831. These bases are cast in the usual manner and after being united to each other are soldered to the abutment caps mesially and distally, or in the case of an extension saddle mesially to the crown serving as an abutment and distally to the saddle, leaving the connecting rings suspended between these points, as in Fig. 832. The crowns are then placed in position in the bases and the buccal and lingual sides between the bases and saddle filled in with wax, and carved so as to restore the gum contour, leaving nearly one-eighth of an inch of the edge of the saddle exposed, and coming about midway on the labial and lingual side of the ring bases. (Fig. 833.) Impressions are then taken of these carved surfaces and models prepared. Dies and counter-dies

Fig. 832

Fig. 833

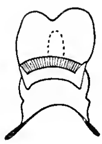
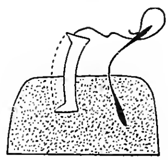


Fig. 834



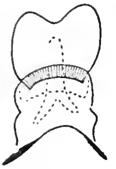
are made and plates of 28 or 30 gauge coin gold struck up and carefully fitted and adjusted to the saddle. The wax is then removed and the crowns taken from their bases. One of the plates is put in position and held in place with a clamp over the edge of the saddle and the piece placed in the investment, open side down, leaving the side on which the plate is to be soldered exposed, as in Fig. 834. The investment is dried out and the inside of the ring bases coated heavily with whiting or other anti-flux. The piece is then well fluxed between the plate and the saddle and also between it and the rings, which are thoroughly united with solder, preferably 20 carat.

After it has been removed from the investment, it is cleansed. The plate for the opposite side is then clamped in position and the piece invested and soldered in the same manner as the first. (Fig. 834.)

The object in making a saddle in this way instead of casting what might be called the entire shell, and then uniting it to the saddle, is that in the rolled coin gold plates we have a perfectly dense homogeneous mass that can be easily polished and which takes and retains a very high finish, while the surface of a casting is more or less porous and will not take a

high polish. It also is much lighter and stronger than it could possibly be made by casting.

FIG. 835



The saddle is cleansed in acid and polished and is ready for the crowns. The crowns are fitted with posts which extend through the opening in the bases into the body of the saddle. These posts are cemented into the crowns, the hollow body of the saddle filled with cement, and the crowns put in place and held there under pressure until the cement is hardened. (Fig. 835.) A saddle made in this way presents a most beautiful appearance and does away entirely with the showing of the gold. At the same time we have obtained a maximum amount of strength with a minimum amount of weight.

PORCELAIN CROWN- AND BRIDGE-WORK.

In the discussion of porcelain work many matters present themselves for our consideration. Regarded from a purely æsthetic point of view, porcelain is the ideal material of which crowns and bridges should be constructed, but from the practical side other things than appearance must also be considered.

If the restoration of the missing teeth were only made for the purpose of improving the personal appearance of the patient, then porcelain should be used in every case, but this should be a secondary consideration.

The health of the patient, depending as it does to a very great extent on the ability of the masticatory organs to properly perform their functions, demands that the question of utility should be given the first importance.

Porcelain is of necessity, a very fragile material and where great strength is required, it is wholly unsuitable for use.

A tremendous force is exerted by the jaws and widely varying figures are given as to the exact amount. Dr. G. V. Black[1] has estimated the force exerted in mastication as follows. "For the incisors, the maximum force exerted, one hundred and seventy five (175) pounds, minimum force, thirty (30) pounds. For the molars, maximum force, two hundred and forty (240) pounds: minimum force, seventy (70) pounds. Force exerted in masticating tough meats ninety (90) pounds: tender meats, thirty (30) pounds. Hard crusts resist a pressure of two hundred and fifty (250) pounds; hard candy, one hundred (100) pounds."

There is no porcelain body made which can successfully withstand the continuous strain to which a bridge will be subjected.

Undoubtedly, porcelain has its place in crown-and bridge-work, but until some method is discovered whereby it can be annealed so as to render it tough and to a certain extent pliable, its uses will be limited to single crowns and bridges on which there will be very little strain.

For single crowns where there is sufficient depth to allow of a con-

[1] The Dental Cosmos, vol. xxxvii., p. 474.

siderable amount of body being used, porcelain can be employed with good results. Where teeth have been lost and much absorption has taken place, so that there is a great depth between the gum and the occluding teeth of the opposite jaw, porcelain will make a much more artistic piece of work, but it can never be as serviceable as a well made and perfectly articulated gold bodied bridge. If porcelain is used, the work should always be made removable, or it should be set in such a manner that it can be easily removed for repair in case of accident, for such a bridge cannot be repaired in the mouth.

Where an upper or lower plate is worn, a porcelain bridge has a much better chance of a long period of usefulness for a time, than where it occludes with the natural teeth, for the force exerted in mastication is very much less where a plate is used.

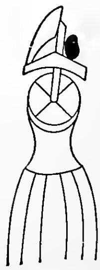
In all cases where porcelain is used, the bulk of body must be as great as it is possible to make it. It should never be placed in thin layers over bands or any of the attachments or metal work of the crown or bridge. Sooner or later the porcelain is sure to flake off, exposing the platinum, rendering the piece unsightly and leaving sharp ragged edges of porcelain to cut and irritate the soft tissues.

If the root of a tooth which is to be crowned sets inside of the arch, so as to necessitate the setting of the facing beyond the labial side of the cap, it should be carried far enough over to allow of placing a thick rope of porcelain over the band, which should be well stippled in order to give a mechanical hold for the body.

WORKING OF PORCELAIN BODY.

In the putting on of the porcelain body, it should not be worked too soft, but should be of the consistency of very thick dough or putty. The pin of the bridge or crown is grasped in the jaws of a pair of suitable pliers or of a pin vise and a portion of the body placed on the cap as in Fig. 836, and carried under the facing and over the cap by tapping the vise or by raking back and forth across it with a rough handled instrument. This will cause the body to spread, bringing the moisture to the surface, which should be taken up with bibulous paper or a clean napkin. More body is added as needed, taking up the moisture as before, until the crown is built up sufficiently, after which it is carved to represent the tooth which it is designed to replace. It is now ready for baking.

Fig. 836



THE BAKING OF PORCELAIN.

The best results in the fusing of porcelain, as in many other things connected with this work, are only secured after long experience. The first baking is called a biscuiting. In a perfect biscuit, the body must be thoroughly fused, presenting a somewhat granular appearance, but

is not perfectly glazed. The porcelain is strongest at this point. For the biscuit body, it is well to use a high fusing body and for the final baking, a medium fusing body, or enamel.

When the body is fused, there is a certain amount of shrinkage, about one-seventh of its bulk, and also some checking of the body. The crown is replaced in a pin vise and built up a second time, with the medium body, or enamel, in the same manner as before and given a second baking, this time glazing perfectly. It may be sometimes necessary to give it more than the two bakings.

PORCELAIN BRIDGE-WORK.

The general plan and methods followed in this class of bridge-work are those of Dr. E. Parmley Brown, who originated it.

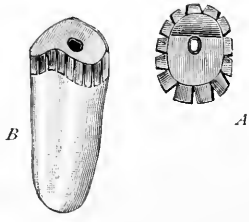
The objections urged against bridge-work composed of fine gold and porcelain facings united by means of fine solders—that the spaces between the gum and the palatal surfaces of bridge were unclean; that the oxidation of the base metals of the solder permitted the accumulation of offensive materials; and that the porcelain facings were, through lack of bulk, in constant danger of fracture—led to the devising of this method, designed to overcome the several objections specified.

The bridge as made and recommended by Dr. Brown consists of a rigid supporting and anchoring bar, to which are adapted porcelain teeth, subsequently united to the bar and to one another by means of porcelain fused about the parts.

The usual method of anchoring the bridge is by means of arms extending from the ends of the bridge, which are anchored in cavities formed in the natural teeth for their reception. Instead of what are called "self-cleansing spaces," the base of the bridge presses firmly upon the natural gum, with a view to excluding even the secretions of the mouth. A base-plate of iridio-platinum may be accurately fitted to the gum, to which the porcelain of the bridge is to be attached.

A typical case for the application of this variety of bridge is that of the bulkhead—two canine roots supporting six artificial crowns. The

Fig. 837



abutment roots are prepared, a platinum cap fitted to each; the edges of the caps are left projecting beyond the edges of the roots, then slit (Fig. 837, *A*), bent over, and adapted to the walls of the roots in the mouth (Fig. 837, *B*). The root-canals are enlarged and deepened, and metal posts filed to fit them are placed through openings made through the

caps into the root-canals. A bite is taken; then an impression is obtained, in which the caps and wires are withdrawn. An articulating model is made, and facings selected and ground into position. The

FIG. 838

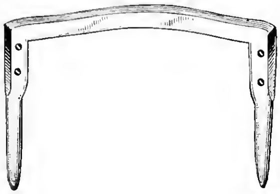
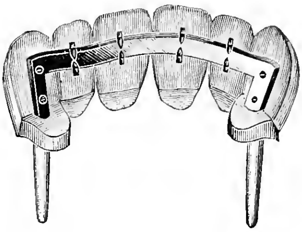


FIG. 839



Porcelain metal band.

face of the cast is varnished and oiled, and a plaster wall formed about the teeth and cast, holding the former rigidly in position. A piece of annealed brass wire, three inches long, has one extremity filed to occupy the pulp-canal of a canine root to the depth it is designed to carry the anchoring bar; the wire above the cap is flattened to a distance which shall permit perforating it for the reception of the pins for the canine teeth. The wire is bent at right angles, then carried across the posterior surfaecs of the incisor crowns; it is to occupy the space between the pins of these teeth. Above the upper pin of the opposite canine crown it is again bent at right angles; the lower end is shortened to adjustment with the depths of the pulp-canal. This wire forms a pattern which is reproduced in iridio-platinum wire from No. 13 to 15 gauge, which is annealed and flattened so that a portion of it will present a flat surface to the backs of the canines, and the transverse portion flattened to rest upon the backs of the incisors between the pins. The wire is bent to the conformation of the brass wire pattern (Fig. 838).

The caps over the root-faces are loosened, returned to position, and the iridio-platinum bar set in position. The wall holding the porcelain facing is applied, and the perpendicular arms of the flattened wire perforated for the passage of the pins of the canine crowns. The wall is removed, the bar is cemented to the caps, and these and the bar withdrawn from the model invested and soldered with the minimum of pure gold. The piece and teeth are boiled in a 1:3 sulphuric-acid solution. The bar caps are set in position on the cast. The teeth are returned to the plaster wall, the pins of the canine crowns passing through the perforations in the bar. The pins of the incisor crowns are bent over the bar, holding each tooth in position. The wire may be grooved or notched at the site of the pins to form retaining slots. The piece is now carefully lifted from the cast and prepared for the application of the porcelain (Fig. 839).

Depressions are made in a fire-clay slab which shall support the bars and the teeth. Porcelain body, made into a paste with water, is applied, giving a contour in consonance with the articulation and the contact with the soft tissues. The body is applied as the second body of a

continuous-gum piece. It s set on the supporting slab, and the porcelain fused in a proper furnace, as with continuous-gum pieces.

Gum contour of similar cases may be restored after the following method: caps are fitted to the prepared 'canine roots as for the preceding case. A pair of canine facings are selected, and also four incisors of the continuous-gum variety. The canine caps are set in position and an impression in modelling composition taken, which presses firmly upon the anterior gum. A cast of investing material, and next dies, are made, and an iridio-platinum plate No. 32 is swaged. This plate should extend upon the outer alveolar wall as high as it is desired

FIG. 840

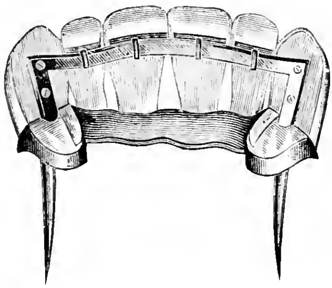
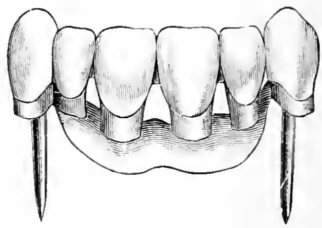


FIG. 841



to have the artificial gum. At its palatal aspect the edge should be formed to represent about the usual neck sections of natural incisors. The lateral edges of the plate should overlap or lie firmly against the sides of the canine collars, to which it is united by means of a small amount of 24-carat gold as solder. The piece is transferred to the mouth; wire posts the size of the canals are fitted; a bite and next a plaster impression are taken. A cast of investing material is made and an articulator mounted.

The porcelain teeth are now adjusted to position; the incisors, as though for the usual continuous-gum operations, and their stays are fitted to the teeth; a support and posts of the form previously described are adapted, over which the pins of the incisors crowns are bent (Fig. 840). More investing material is applied to cover and protect the porcelain, and the teeth are united to the bar and stays, and the posts to the collars by means of the minimum of 24-carat solder. Fig. 841 shows labial aspect. The porcelain is next added. Sufficient body is applied to give the desired contour, the piece is baked, and the gum enamel is then added and a final baking given.

CHAPTER XVIII.

HYGIENIC RELATIONS AND CARE OF ARTIFICIAL DENTURES.

By Charles J. Essig, M.D., D.D.S.

There can hardly be room for doubt that a well-planned and properly adjusted artificial denture contributes to comfort and health, and prolongs the life of the individual who by reason of premature loss of the natural teeth finds it necessary to wear one, but the usefulness of the fixture and its influence on the mind and general health of the patient depend very largely upon the manner in which it is planned and constructed. It may be made an instrument of discomfort, if not of torture, by constructing it upon a faulty impression. It may entirely fail to meet the demands of a masticating apparatus by imperfect articulation of the teeth. It may so interfere with speech, through want of adhesion, that the wearer is at all times conscious of its presence, and he is thus sometimes forced to give up social intercourse, or if, as in the case of lawyers or clergymen, professional duties require the individual to address audiences, the patient feels that his usefulness is abridged, and mental depression and departure from a normal standard of health follow.

Prosthetic dentistry requires in its successful practice good judgment, artistic taste, and a high degree of manipulative ability. No two cases are ever precisely alike, and each one demands careful study and a definite plan of procedure. The choice of material, means of attachment, style of teeth, and the arrangement of the latter to ensure the greatest attainable degree of efficiency in mastication are to be considered.

With the materials at the present time within the reach of every prosthetic dentist, and the light of the experience of other workers in that branch in the recent past, it is not claiming too much to say that artificial dentures may be so constructed and adjusted to any or all mouths as to restore the functions of mastication and speech, as well as natural appearance, in a manner but little short of absolute perfection.

The pathological conditions incident to the use of artificial dentures may be local or systemic. Many morbid phenomena of a local character may be observed as resulting from their presence in the mouth, and marked constitutional disturbances have been traced to the same causes.

In the insertion of an artificial denture a foreign body is introduced into the oral cavity which may act as an irritant to tissues and organs with which it comes in contact. This it particularly liable to occur in all lower dentures. on account of the pressure being confined to a nar-

row area and the muscles and integuments being attached well toward the top of the ridge, as in the case of the buccinator muscles; painful abrasions frequently result in this class of cases soon after the introduction of the fixture. Abrasions produced by undue pressure of the edge of a plate cause an amount of discomfort and suffering entirely out of proportion to the extent of the injury. To avoid a continuance of this trouble and to give immediate relief the patient should always be cautioned to return the moment the presence of the denture becomes painful.

Artificial dentures are held in place by atmospheric pressure, by adhesion, by clasps, by spiral springs, or by permanent or removable attachments to natural teeth or roots. Either of these may become the cause of irritation to the teeth or contiguous parts. In the case of clasps the tendency invariably is to produce morbid phenomena, and this tendency is increased or lessened by the character of the materials of which they are made, and the manner in which the clasps are adjusted and the parts of the teeth embraced by them.

The result produced by clasping natural teeth is a loss of tissues, either through caries, mechanical abrasion, electro-chemical action, or by the joint action of all three. The rapidity with which the disintegrating process advances depends largely upon the quality of the tooth-substance, the condition of the oral fluids, the size and form of the clasp, the portion of the tooth which is embraced by it, and the material of which the clasp is constructed.

A partial lower denture must be secured either by clasps or contact with natural teeth. In that class of partial lower dentures designed to replace the second bicuspids and molars on each side clasps adjusted to the first bicuspids are generally employed: caries of the approximal surfaces of the first bicuspids is more or less quickly induced, probably because the enamel is thin at that point. Incipient caries, produced by clasps at the positions above indicated, manifests itself by great sensitiveness of the tooth, which is exceedingly painful when exposed to extremes of temperature and certain kinds of food, such as very sweet or salt articles. Painful mechanical abrasions are frequently caused where mere contact with natural teeth is the means adopted for securing stability to partial dentures. Badly-fitting clasps, as may be expected, rapidly hasten the progress of caries by favoring the lodgement between the tooth and clasp of particles of food mixed with the oral fluids, which undergo fermentative decomposition and produce agents destructive to the enamel and dentine.

Clasps should be accurately fitted to the broadest part of the tooth, which is usually found at or near the masticating portion of the crown, and never at the necks of the tooth. They should not be allowed to impinge upon the gum, as recession of that tissue and exposure of the cementum, with subsequent softening and caries, will almost certainly supervene.

While the result of observation as to the effect of clasps upon the natural teeth is undoubtedly in all cases unfavorable, yet there are many instances in which clasps are indispensable, and their capacity

for doing harm may be very greatly reduced by adjusting them with accuracy to the most convex portions of the teeth, avoiding impingement upon the necks and cementum.

It has been observed that clasps exert an influence upon teeth varying in degree according to the condition of the oral fluids and the kind of metal of which they are made. Silver clasps have been found to exert a much more rapid disintegrating influence than those made of gold. Dentures with clasps or attachments made of platinum or iridio-platinum act more injuriously than the same appliances fitted with gold clasps. These differences in the effects of the metals upon the teeth are probably due to a galvanic current between the tooth-structure and the metal forming the plate, aided by certain conditions of the oral fluids.

Silver and platinum should not be used in the formation of clasps, or indeed for any purpose which demands contact with tooth-structure. It has been observed that teeth in contact with a platinum wire employed as a means of retention, their positions having been changed in the correction of irregularities, exhibited erosions in a comparatively short time after its application.

An example of the action of silver upon the natural teeth was observed a number of years ago in the case of a man who had in an election fracas sustained a severe fracture of the jaw. When he presented himself for treatment at the college clinic, nearly a year after the injury had been received, it was found that the jaw was in three parts, no union having taken place. He had received a blow from some heavy instrument upon the mental portion of the bone; the fractures were on each side between the first and second bicuspids. The individual, for some reason best known to himself, had been obliged to remain in concealment for several weeks after the injury, during which time he received no surgical treatment whatever. The appearance of the lower part of the face was greatly changed by the displacement of the disunited parts of the jaw, and mastication was impossible. As a temporary or palliative remedy for the latter difficulty a dental surgeon had fitted a bar of stout half-round silver wire entirely around the lower teeth, so as to hold the parts in juxtaposition and restore the articulation of the teeth. The individual had not worn the fixture many weeks before the posterior surfaces of the second molars, where the brunt of the force was borne, became unbearably sensitive. An examination showed deep grooves in these teeth, rapidly approaching the pulps. As the neighboring teeth appeared of good quality and entirely free of caries, the abrasion on the second molars was probably due to galvanic action between the silver support and the tooth-structure.

The wearing of artificial dentures at night is a subject upon which there is much difference of opinion. It may be advisable in the case of a full denture for either or both jaws, particularly in the beginning of its use by the patient, for its presence in the mouth except at such times as it has been removed for purposes of cleansing enables the patient to more speedily become accustomed to its use.

There is hardly room for doubt, however, that disintegration of the tooth-substance when clasps are used is likely to proceed much more rapidly where the piece is worn continuously; besides, careful observation has shown that at night the oral secretions assume a slightly acid character. This has been demonstrated particularly in patients subject to enamel erosion by carefully testing the oral secretions with litmus after waking and before the salivary fluids have started their usual flow.

If the necks of the teeth are highly sensitive or there is well-marked tendency to softening or erosion of the tooth-structure, the patient should be directed to remove the plate each night before retiring, and to apply to the affected teeth, after thoroughly cleansing, a small quantity of precipitated chalk, lime-water, or milk of magnesia.

Too much stress cannot be laid upon the necessity for cleanliness, and every patient who wears a denture secured by clasps should be particularly instructed in the means of removing the deposits which are usually found on the inside surfaces of the clasps. This is not generally well done by patients with the tooth-brush alone, so that a piece of soft wood armed with fine pumice is necessary to do it thoroughly, and the addition of aqua ammonia is efficacious.

Patients suffering from any chronic conditions of the system which are likely to be accompanied with acidity of the oral fluids must be cautioned to exercise the most scrupulous care in cleansing the artificial denture; and this caution is particularly demanded when partial dentures are worn. In these cases lime-water and bicarbonate of sodium are recommended as alkaline mouth-washes, which by neutralizing the acid condition of the fluids are often effective in preventing sensitiveness and the tendency to softening of the tooth-substance.

In the mouths of young persons whose teeth show unmistakable evidences of a tendency to rapid decalcification clasps should never be employed; and this is a matter to be decided by the dentist himself even when the patient expresses the strongest preference for the small plate attached by clasps and an equally forcible objection to the larger atmospheric plate.

Of the hygienic relations of spiral springs, which as a means of retaining artificial dentures antedated all other devices now in use, very little need be said, since the appliances are no longer used except in rare cases of edentulous mouths complicated with cleft palate, wherein adhesion would be impossible. Three principal objections may be urged against the employment of spiral springs for the retention of ordinary dentures, as follows: their liability to chafe and abrade the delicate mucous membrane lining of the cheek, the tendency of one or the other to break, and the difficulty of thoroughly cleaning them.

The materials used in the construction of artificial dentures, other conditions being equal, do not differ to any great extent in their effect upon the tissues with which they come in contact. On the other hand, the frequency and extent of oral irritation associated with the wearing of artificial dentures, irrespective of materials employed, varies with different individuals. It is not, however, denied that modifications of

that portion of the surface of the mouth covered by the artificial denture is more frequent in cases where rubber and celluloid are worn. The author has always believed that the real cause of the inflammatory conditions so generally attributed to vegetable bases will be found in the following conditions: (1) the non-conducting quality of the substances; (2) the rough condition of the surfaces of the majority of rubber or celluloid dentures, due to carelessness or want of skill in construction; (3) want of care on the part of the wearer in not frequently cleansing the denture of deposits of food and secretions of the mouth, which are likely to undergo chemical change by long confinement in contact with the tissues, and thus become irritants. Either one or all of the conditions named may cause inflammation of the mucous membrane, but always, so far as the author's observation has gone, limited to the area covered by the plate. Similar conditions are frequently noticed when the dentures were of gold or silver, but always in cases where the plate was seldom removed or cleansed. And if the trouble referred to is more common in rubber or celluloid dentures than where metallic plates are worn, there are doubtless more conditions favoring such a result in the former than are found in the latter; and the facts that the symptoms are not constant, and that by far the greater number of mouths in which rubber or celluloid is worn are not in the least affected by it, would seem to confirm the view that the inflammation referred to is due to contact with irritating products of food and secretions, and that these are equally active in all dentures, irrespective of the material of which the dentures are made.

Rubber sore mouth as described in the *American System of Dentistry,* if met with at all, must be exceedingly rare, and the "rubber sore mouth" which passes the stage of redness and slight tenderness and extends to the tonsils and walls of the pharynx, with the parts greatly swollen and painful, rendering the wearing of the plate impossible for the time and the formation of abscesses, the author has never seen.

Acute inflammatory conditions of the mouth which appear with some degree of suddenness may often be traced to persistent efforts on the part of the patient to obtain adhesion through atmospheric pressure in a badly-fitting denture by powerful suction of the tongue in the effort to exhaust the air from the chamber: violence of this kind, aided by the other unfavorable conditions referred to, may cause occlusion of mucous follicles and the usual inflammation resulting from interruption of the secretions; but it would be manifestly wrong to class such conditions under the heading of "Rubber Sore Mouth."

The great majority of cases of local irritation associated with the wearing of dentures are not usually cases calling for the exhibition of drugs, but as the rules of hygiene extend to all conditions which may cause departure from a normal standard of health, whether local or general, the first step in the treatment of so-called "rubber sore mouth" should be an examination of the plate to determine—1st, if there is accuracy of adaptation; 2d, is the surface of the denture smooth enough, and in proper condition to be constantly worn in contact with the deli-

cate tissues of the mouth? 3d, is the denture free of deposits of food and secretions? A cure will usually be promptly effected by the fulfilment of the three conditions named.

Rubber dentures favor the deposition of material composed of food and mucus secreted from the follicles of the tissues covered by the plate, which often escapes the observation of the patient and is always difficult to remove thoroughly. The patient should be carefully instructed as to the best means of keeping the denture free from this deposit, which will consist in the frequent use of a strong solution of soda, in which the plate should occasionally remain immersed over night, and when the deposit is thoroughly softened by the soda solution, the careful use of the tooth-brush armed with soap and tooth-powder. Salivary calculus, which often deposits in large quantities on lower plates, may be removed by immersing the denture over night in vinegar and water; but if crowns of natural teeth have been reset on metallic plates, the salivary calculus must be removed by instruments, as any form of acid would dissolve the enamel and ruin the teeth.

If a chronic state of inflammation of the surface covered by the denture has become established by violation of the conditions essential to maintenance of a normal state of the oral tissue, local applications of phenol sodique, thymozone, or listerine, diluted in the proportion of one part of the remedy to three or four of water, will generally relieve the tissues of redness and tenderness.

In cases of long standing and unusual severity zinci sulphas in solution, in the strength of gr. j or ij to f℥ss of water, will be found of great service as an application to the inflamed parts.

Some authorities state that chronic stages of so-called "rubber sore mouth" are curable only by the substitution of a denture made upon metal. Such cases the author has never met with, and he believes that careful fulfilment of the conditions of precision of adaptation, smoothness of surface in contact with the tissues, and absolute cleanliness will generally be found sufficient to restore the mouth to a normal state.

Excessive absorption of the alveolar ridge, ending in the entire obliteration of any semblance of a ridge, is extremely rare, and not a single instance of the kind has been met with by the author in his entire practice. The few cases of absorption of the anterior portion of the ridge which have come under his notice have been mouths in which metal plates have been worn. This phenomenon has been attributed to the poisonous action of vermilion used in dental rubbers as a pigment; imperfect vulcanization, causing porosity of the plate, thus favoring the absorption of secretions or the growth of micro-organisms on that portion of the plate in contact with the mucous membrane; but it is quite probable that excessive absorption of the alveolar ridge is an inherited tendency. The author has observed that condition in more than one member of the same family, where the anterior portion of the alveolar ridge has quite disappeared, while the ridge in the posterior part of both mouths is unusually broad and prominent. It is also most commonly caused in this portion of the mouth by the impact

of the lower anterior natural teeth, the posterior teeth of the mandible having been lost, and the artificial denture in the upper jaw sustaining in the front the whole force of mastication.

Pure vermilion, in combination with rubber, is not likely to produce deleterious effects when worn in the mouth, nor is it probable that this compound can be decomposed chemically and converted into a poisonous salt of mercury by mere contact with the saliva.

The mechanical dentist will, however, do well to avoid the use of nitrohydrochloric acid in removing tin-foil from the surface of unfinished vulcanite dentures. (See chapter on Metallurgy: Mercury.)

Regarding the presence of free mercury in rubber before or after vulcanizing, Prof. Austin stated that the researches of Prof. Johnston with the microscope, and of Prof. Mayer by chemical analysis, failed to discover the slightest trace in samples of that which had been used for several years. Prof. Wildman observed that sulphur sublimed during vulcanization, but did not find the smallest trace of free mercury. Prof. Austin further stated that he never during his entire experience with indurated rubber as a base for artificial dentures detected the slightest particle of metallic mercury on the surface of any finished piece.

In the belief that mercuric sulphide (vermilion) may be the cause of the different phases of so-called rubber sore mouth, the substitution of black for red rubber has been recommended as a means of overcoming the tendency to excessive tenderness of the mucous membrane covered by the plate. Black rubber is but a doubtful improvement upon the red variety so far as influenec on the health of the tissues is concerned. As it contains lampblack as a pigment, it is uncertain whether it is more dense and less liable to absorb secretions. The best quality of rubber for dental purposes, the one affording the greater density of surface, is that which is composed simply of caoutchouc 48 parts, sulphur 24 parts, without any pigment whatever. This rubber is of a dark drab color and it differs so widely from the color of the tissues that it has never been employed to any great extent in prosthetic dentistry.

Vulcanizable rubbers, of whatever composition, require great care both in investing and indurating. Campbell, the inventor of the "New Mode Heater for Rubber and Celluloid Work," demonstrated that the only way to obtain fine texture and density of surface in rubber and celluloid is to expose them to low temperature, dry heat, and contact with metallic surfaces.[1] This produces a harder rubber, less porous and less liable to absorb the secretions than can be obtained by contact with plaster, or indeed by any other means; but where the modus operandi suggested by Drs. Campbell and Evans is practised, the preliminary "waxing" of the case must be done with such precision that the surface thus obtained need not be subsequently disturbed by the scraper. (See chapter on Vulcanite Work.)

[1] The manufacturers of rubber articles of jewelry and ornamentation long since abandoned the use of steam as a heating medium and plaster as an investment.

The theory presented by Dr. G. V. Black, that the sore mouth produced by artificial dentures is due to the growth of certain fungi which elaborate an acid secretion which acts as an irritant to the mucous membrane, is probably correct. He asserted that he found these fungi upon the surfaces of all plates without regard to the material of which they were constructed, but in the greatest number upon the surfaces of vulcanite dentures; which he attributed to the fact that the irregularities and roughness of the surfaces of such plates afforded lodging-places where they rapidly developed on account of the greater difficulty in thoroughly cleansing them, and he regards absolute cleanliness as a complete protection from inflammation.

Prof. E. C. Kirk stated, as the result of repeated tests of the mucous secretion in cases of sore mouth associated with the rubber denture, that the mucus in such cases generally showed an alkaline reaction as it was eliminated; and he suggests the possibility that alkaline sulphides might be eliminated to a sufficient extent to exert a slight solvent action upon the mercuric sulphide of the plate, and thus form an active salt of mercury. But this theory seems to be at variance with the more practical reasoning and experience of many others who have given much thought and attention to the subject. Prof. Kirk's suggestion, however, that the non-conducting quality of the vegetable bases plays an important part in the production of every kind of inflammatory action undoubtedly carries with it much force, for, as he states, "the effect on the tissues continually enclosed by the non-conducting plate is to maintain a hyperæmic condition, with slight increase of temperature: this in addition to the pressure, which, if it does not result in inflammation, is a source of irritation sufficient to bring about greatly increased functional activity of the cells of the parts."

It was at one time thought, and so claimed by many of its advocates, that the substitution of celluloid for rubber dentures would prove an effective remedy in cases of sore mouth; but that material is open to the same objections as rubber, and to a greater degree in consequence of the sponginess of surface incident to the evaporation of camphor.

Partial artificial dentures immovably attached to one or more natural teeth or roots of teeth, or the attachment of several crowns to one or more roots as in bridge-work, present many points for consideration from a hygienic standpoint. The operation of substituting an artificial crown for a natural one should not, if properly performed, affect the integrity of any of the surrounding tissues, and yet if the work is ill-fitting and done in a slovenly manner, with the cap or ferrule extending so far under the free margin of the gum as to impinge upon the alveolar border of the socket, persistent irritation may be established which can only end in disorganization of connective tissue and loss of the root if the cause be not removed. The experience of the author has been that roots upon which artificial crowns have been fixed are less liable to pericemental inflammation and abscess than are devitalized teeth with natural crowns, the greater success in the treatment of the crownless root being probably due to its accessibility and the better

opportunity which undoubtedly exists of filling the latter with thoroughness to the full extent of the canal. The fact, too, of restoring occlusion, whereby roots are brought into use, helps to keep them in a healthy condition, and prevents their gradual extrusion and premature loss from the alveoli.

As is well known, there are a variety of methods of setting artificial crowns to roots. Any one of these methods, if lacking in the element of precision of adjustment, may favor the establishment of pathological conditions. The Richmond crown, properly so called, with an accurately fitted cup or ferrule, is perhaps less liable to cause irritation to the surrounding tissues than any of the methods of crown-setting in use.

The worst results have been noticed in that class of crowns, without caps or ferrules, in which the attachment to the root is secured by means of amalgam. If the latter is allowed to project at the point of union of the crown and root, it soon becomes exceedingly irritating to the margins of the gum—a condition marked by redness, tumefaction, and a tendency to bleed, particularly in the recumbent position at night, and a nocturnal flow of saliva similar to that noticed in pyorrhœa alveolaris becomes established. The only remedy for chronic dental irritation due to this cause is the removal of the crowns and the substitution of others which are not dependent upon amalgam as a means of attachment.

Bridge-work, which consists of the bridging of interdental spaces by one or more crowns fastened together and attached to natural teeth or roots, frequently causes pathological conditions from a want of care and exactness in their construction, and by requiring two or more roots to sustain an amount of force in mastication greatly in excess of that for which they were intended. As a result of the excessive strain to which they are subjected under such conditions, fracture of the roots, chronic inflammation of their pericemental membranes, abscesses, or protracted tenderness may occur, either of these being sufficient to seriously interfere with mastication and render the denture useless.

Cases of serious local irritation from unusual causes are occasionally met with in so-called bridge-work. The author once met with a case in which a bridge had been constructed for the purpose of replacing two right upper bicuspids. The attachment consisted of a wire of ordinary 18-carat gold fastened with amalgan in the canine and first molar, both of which were devitalized. The wire had gradually yielded under the pressure of mastication until the necks of the two artificial teeth had become imbedded in the gum tissues, which were so much swollen that only the points of the porcelain teeth were visible. The general health of the patient was greatly affected by the persistent irritation caused by the displaced bridge: no time was therefore lost in removing it. This was done with the greatest relief to the patient, the tissues returning within a few days to their normal condition.

Although skilful and experienced bridge-workers generally plan and construct dentures of this class with special reference to complete cleanliness, yet it is doubtful whether all parts of the best of them can be

reached by the tooth-brush as thoroughly as is the case with the ordinary removable denture. In many cases the irritation induced by the impaction of food-débris and fermenting secretions, and the unusual strain upon roots of diseased teeth, will cause hypertrophy of the surrounding tissues or rapid loosening from absorption of their alveolar borders. These conditions are always accompanied by more or less vitiation of the secretions of the mouth and foulness of breath, constituting in many cases potent arguments against their introduction.

Of the different methods of constructing this class of dentures, the removable bridge is probably open to fewer objections than any of the other forms; yet even that plan requires good judgment in determining the capability of teeth or roots to sustain the extraordinary strain to which they must necessarily be subjected, and the greatest skill and care in the construction and adjustment of the different parts of the fixture.

The introduction of immovable "bridge" dentures has undoubtedly in a great many cases caused so much discomfort and irritation to surrounding tissues as to render mastication almost impossible, and it is doubtful whether extensive operations of this class, considered from their hygienic relations, are as satisfactory as properly planned and constructed removable dentures retained in position by atmospheric pressure.

Care in cleansing artificial dentures of whatever form, size, or material is of the utmost importance. The cleansing should be performed immediately after eating, and particularly before retiring for the night. If this be not done with some degree of thoroughness, débris of food mixed with saliva and mucus forms an adherent mass upon the plate which undergoes fermentation and decomposition, with the result of irritating the mucous membrane and producing a general inflammation of the oral cavity, and the irritation of the oral secretions may cause serious derangement of the digestive function.

It is the duty of the dentist to instruct his patient as to the importance of cleanliness and in the proper means by which that result may be accomplished. The thorough cleansing of an artificial denture, although appararently a simple operation, seems to be a matter of great difficulty to the majority of patients, and but few are capable of maintaining a faultless condition of their dentures; yet the tooth-brush armed with soap and ordinary tooth-powder is quite sufficient to maintain a clean and highly polished surface. The patient should be cautioned against the danger of bending partial lower dentures of gold or other metals by grasping them with too much force while brushing, and in the case of vulcanite dentures to avoid "boiling them out" in hot water. Many individuals who have previously worn gold dentures resort to that means of ridding the fixture of deposits of food, etc. which have found a lodgement under the teeth and behind the backing. The author has met with several instances where recently constructed vulcanite dentures have been completely ruined within a short time of their completion by immersion in boiling water.

In the construction of metallic plates for partial dentures the plate should be accurately fitted around remaining natural teeth, so that there will be no spaces between the plate and the teeth to admit of pinching of the gum between the edge of the former and the neck of the tooth; and where a point of the plate extends between two teeth—as, for instance, the central incisors—such projection must be made to fit the space accurately, or it will be certain to cause inflammation which may result in permanent impairment of the teeth. Defects of this kind may be corrected by soldering an addition to the edge of the plate in order to bring it almost in contact with the teeth, or else by cutting away the plate so freely that its distance from the teeth will preclude the danger of pinching the tissues.

CHAPTER XIX.

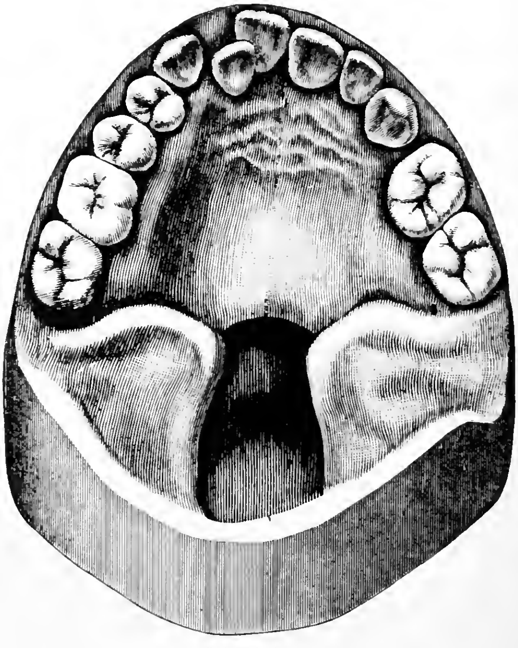
PALATAL MECHANISM

By Rodrigues Ottolengui, M.D.S.[1]

CLEFT PALATE.

Cleft palate may be divided into two classes—acquired and congenital. Acquired lesions include all of those cases where the individual, having been born with a normal oral cavity, later in life suffers

Fig. 842



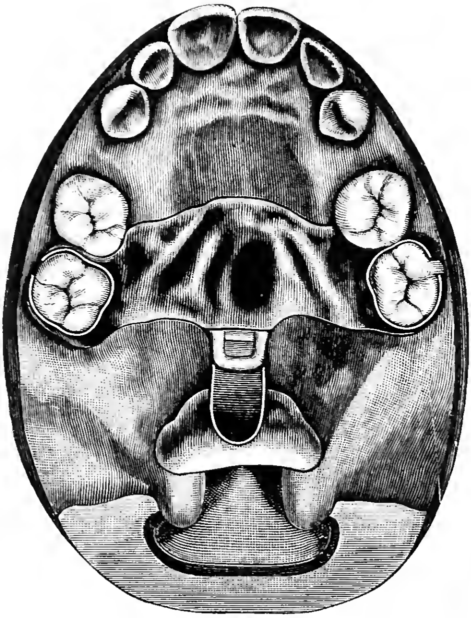
a division of the hard, or of the soft palate, or of both. This unfortunate mischance may be caused by an accident; or it may be the sequence of disease, usually syphilis; or the result of a surgical operation for the removal of malignant growths.

The acquired lesions may be very slight, as a mere perforation of the hard palate, or they may be most extensive in character, comprising a

1 I am indebted to Dr. Norman W. Kingsley for the use of his large collection of models from which to choose for illustrations, as well as for the privilege of referring to cases from his practice in order more clearly to expound the theories and principles set forth.

complete cleft of the hard and soft palate, with total destruction of the vomer and turbinated bones, as well as the bridge of the nose, and sometimes the nose itself. Such an extreme case, of course, would only have its origin in disease. Between the two extremes cited an endless variety of cases are found, many of which will tax the ingenuity of the operator to its utmost. The conditions which may follow upon unsuccessful surgical operations frequently add to the complexities of cases. Fig. 842 shows a case, the absence of the uvulæ, and the adhesions which have united the posterior borders of the divided soft palate to the pharyngeal wall, making this case readily distinguishable from one of congenital origin.

Fig. 843



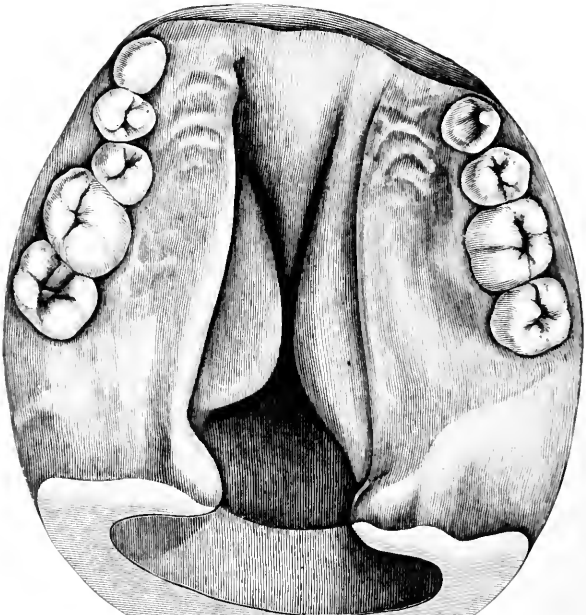
Nevertheless, whether the acquired lesion be of small or great extent, the prognosis is more favorable than in the congenital cases, because it has been demonstrated that if the operator succeeds in replacing the lost parts with an instrument properly constructed and suited to the individual requirements, normal functions will be restored almost immediately. The patient needs but to accustom himself to the new and strange condition in which he finds himself, to be able to speak as well as ever because he had acquired all the normal habits of articulate speech before meeting with disaster. He has lost part of the natural organs with which he was endowed, but, having known their uses, he readily accustoms himself to the artificial substitute, which enables him to produce the same sounds by the same movements of the organs which remain intact. As the instruments to be made for persons suffering from such misfortune are to be constructed on the same gen-

eral principles which must guide the dentist in the treatment of congenital lesions, description at this point is unnecessary.

Congenital cleft palate is a division of the roof of the mouth of more or less extent, which is present in the infant at the time of birth.

Congenital clefts come to the dentist for treatment in one of three conditions: the cleft of the soft palate only, which may extend to the posterior border of the hard palate or be scarcely more than the division of the uvula, as in Fig. 843; the cleft of the soft and hard palate, in which the cleft may penetrate the bony tissue but slightly or pass through the hard palate and also the dental process, obliterating entirely the intermaxillary bones, as in Fig. 844: any of the above conditions com-

Fig. 844



plicated in an endless variety of ways through unsuccessful surgical operations. In these latter cases a most common presentment is a bridging of the gap, with the soft tissues drawn together tensely, leaving an aperture through the hard palate anteriorly and an inadequate length of soft palate posteriorly, the tightly drawn tissues which form the surgical bridge not being long enough to occlude with the posterior pharyngeal wall; or where there has been only a cleft in the soft palate, the cleft is usually found partially closed, with no advantage to the patient, and offering a greater obstacle to the success of the dentist.

In some of these cases the intervention of the dentist is rendered useless, while in those where it is possible to make an instrument, the difficulty of constructing the same is greatly increased, owing to the complexities of the altered conditions.

The modern instrument which the skilled dentist supplies to a cleft palate patient, is either an artificial velum or an obturator, both of which are admirably adapted to the correction of the abnormal speech of these sufferers, and either of which may be requisite in a special case. It may be stated, however, as a rule for guidance in general practice, that *the artificial velum will more quickly enable a cleft-palate patient to acquire the art of speaking correctly,* whilst after having *learned* to speak properly the obturator may afford him equal satisfaction.

At the meeting of the National Dental Association in 1902 Dr. Calvin S. Case presented a novel form of artificial palate which at the time he denominated an artificial velum but which to the writer appeared rather to operate on the principal involved in an obturator, although made of soft rubber, for which reason he would term it a soft rubber obturator. Since then Dr. Case has called his instrument a velum-obturator, this double term apparently depending upon the fact that it is so fashioned that it may first be made of soft rubber, and subsequently the same molds may be utilized, for the making of a duplicate in hard rubber. The device will be described later.

The knowledge of how best to serve a cleft-palate patient, and what manner of instrument is best adapted to his requirements, necessitates an intelligent comprehension of his needs, as well as of the principles upon which obturators and vela are constructed, together with the uses which they are meant to serve.

In the production of articulate sounds the normal individual is supplied with a soft palate, or natural velum, of great mobility, suspended from the posterior border of the hard palate. This natural velum serves two important purposes. First, in the production of many sounds it is necessary to prevent the nasal resonance which would result if the column of air were permitted to escape through the nasal passages. That the nasal and oral cavities may be completely separated, the posterior wall of the pharynx rises, forming a well-defined ridge, against which the velum occludes, being drawn backward and upward to meet it. Thus the sound is forced to pass exclusively through the mouth, and is rendered clear and distinct. Second, the natural soft palate serves as an abutment against which the tongue rises in the formation of such sounds as *k*, *g*, and *ng*.

A cleft of the palate consequently leaves the patient with no means of shutting off the nasal passages, and with an inadequate organ with which to produce the sounds specified, as well as many others.

The artificial palate, therefore, whether velum or obturator, must enable the patient to completely shut off the nasal passages, and it must stop the gap in the roof of the mouth, restoring the normal vault, and rendering possible the production of all the sounds with which the cleft interfered. The artificial velum and the obturator both accomplish this, but their modes of action are quite distinct.

The difference between an obturator and a velum is this—the first recognizes the abnormal condition of the parts, and is so shaped that, with these abnormal parts working against its sides and end, it makes

possible the proper occlusion of the nares in all movements of the palate, so as to produce perfect speech, the obturator itself remaining rigid, and the cleft parts sliding against the lateral sides, these being so shaped that they occlude the cavity when the parts are at rest, and therefore when the cavity is at its widest opening, and they are so slanted that as the parts are drawn together and brought down they slide along the oblique sides of the obturator, continuing the occlusion. The velum

Fig. 845

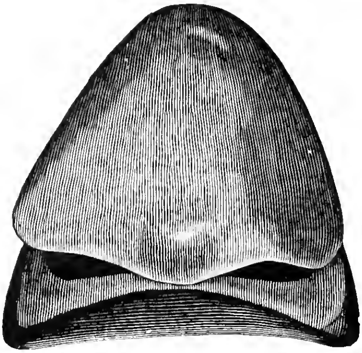
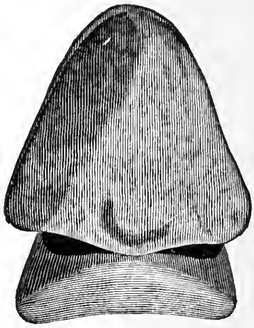
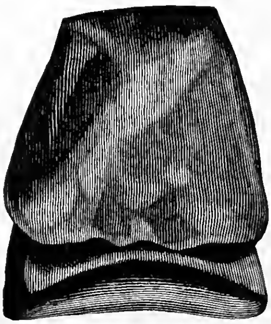


Fig. 846



is a mechanical effort to reproduce artificially the original soft palate which is missing. It is a flexible bridge across the chasm, and should as nearly as possible act as the original tissue did. Therefore, Kingsley arranged his velum so that when it rested the chasm was bridged. The split parts of the artificial velum allowed a resting place for the borders of the cleft soft parts, and the artificial velum was made suffi-

Fig. 847



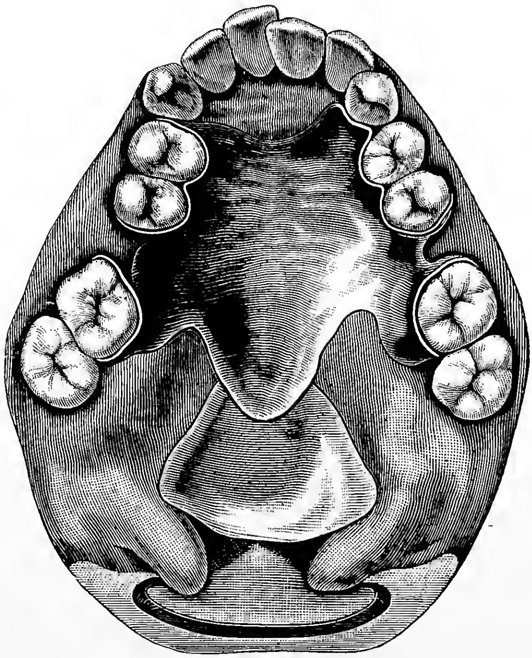
ciently flexible so that in any position they might assume in the closing of the aperture, they would carry along the velum. The obturator is rigid and immovable and the soft parts move against it, while the velum is flexible and movable, and is carried with every movement of the soft parts.

The artificial velum which is the invention of Dr. Norman W. Kingsley, is made of soft rubber (vulcanite), from which fact it is clear that

the theory of its action is to simulate the movement of the natural organ which it replaces. Being exceedingly mobile, it responds to the movements of the muscles which it engages, rising and falling exactly as a natural velum would, while it is so fashioned that at the same time it occludes with the ridge of the pharyngeal wall, completely shutting off the upper passages.

The Kingsley velum (Figs. 845–847) consists of two flaps joined throughout the median line. The lower flap, the one which completes the palatal dome, extends from the apex of the fissure posteriorly as far as the bases of the uvulæ. Its general form is that of a triangle, the apex of which occludes with the apex of the cleft, the base extending across from one uvula to the other. This flap overlaps the soft parts sufficiently to prevent its being pushed through the cleft into the upper

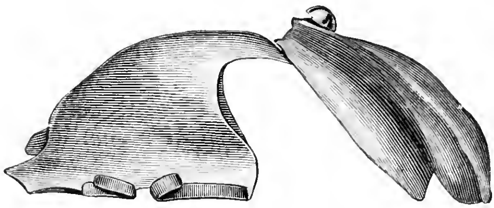
Fig. 848



cavity. The other flap is of a similar triangular shape, the posterior border, however, being curved and thinned out to a feather edge, so that when in occlusion with the pharyngeal wall it curls up, thus presenting a flat surface for better contact, while its thinness prevents irritation to these sensitive parts. This flap is above the fissure and rests upon the upper surfaces of the divided palate. The two flaps are united along the median line, so that when complete they form a single appliance. The flaps having but a narrow line of union, grooves are produced laterally, and when in position the two halves of the soft palate rest in these grooves.

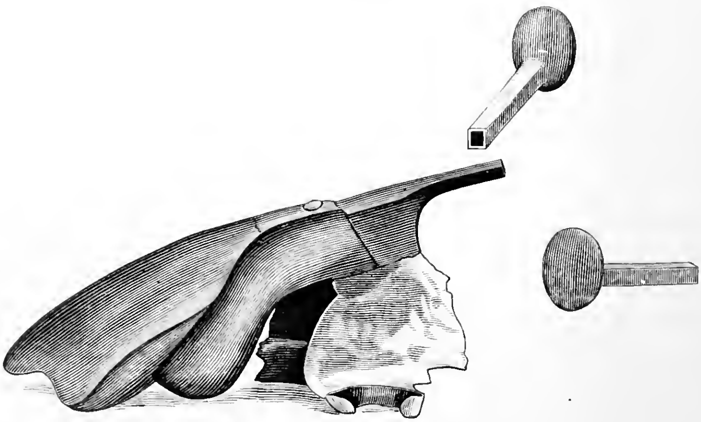
In connection with the artificial velum a metal plate is constructed, clasped to the teeth, having a pin upon the upper surface which passes through a hole in the velum, and thus holds it in place while allowing it lateral motion. Fig. 848 shows an instrument in position, the uvulæ appearing pendant below the grooves of the artificial palate. Note the relation between the posterior border of the velum and the wall of the pharynx. The *rationale* of this appliance is as follows: in the effort to close off the upper passage the sides of the divided natural palate

Fig. 849



approximate each other, and at the same time are drawn upward. Thus they first hug the artificial velum tightly, and then, owing to its elasticity, carry it upward. Coincidently, the wall of the pharynx rises, forming a ridge which meets the feather edge of the artificial velum, curling it up, thus accomplishing perfect contact, completely preventing the escape of sounds through the nasal passages. At the same time the velum, completing the proper arch of the vault, is rigid

Fig. 850



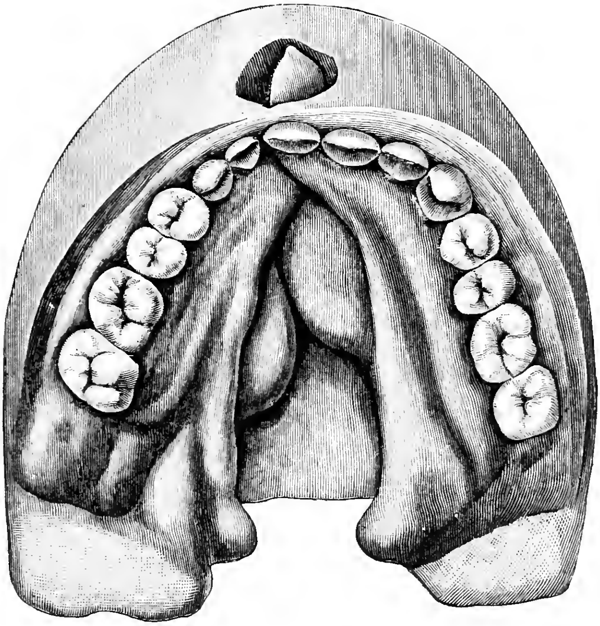
enough to serve as an efficient abutment for the tongue when necessity compels such contact. Fig. 849 shows the upper view of the instrument seen in Fig. 848 and is introduced to give a clearer idea of the attachment of the velum to the plate, as well as the general character of the grooves.

As stated above, the flaps which constitute the velum are triangular in shape, yet it will be observed that the velum shown in Fig. 848 is

square at the anterior end. Where the cleft is in the soft palate only the triangular velum is required, but where the cleft passes forward, entering the hard palate, it is frequently more desirable to fill the aperture in the hard palate by vulcanizing hard rubber upon the upper side of the metal plate, the soft rubber velum having a square end to meet a similar surface of the hard rubber.

Such an instrument is seen in Fig. 850, the abutment of the hard and soft rubber being clearly indicated. The projecting point seen in this figure was for a special purpose, and is not ordinarily required. This patient was a girl aged fourteen, and presented an extensive fissure through hard and soft palate, complicated with a hare-lip, upon which a fairly good result had been obtained by a surgical operation in

FIG. 851



early life. Fig. 851 shows a model of her mouth, the aperture seen above the incisors representing the passage of the fissure through to the nose, but somewhat exaggerated, having been enlarged with a knife for convenience in constructing the instrument. The girl's articulation was bad, but the greatest difficulty of understanding her arose from the excessive nasal quality of her voice. Externally, she was much disfigured by the fact that the ala of the nose, on the side where the hare-lip had been, was more sunken than is usual—so much so, indeed, that the nostril on that side was completely closed. If the reader will read aloud a few lines on this page, and while doing so will close one nostril by pressing down the ala with one finger, he will readily discover that such closure of the nostril produces considerable nasal quality of

voice. Thus it was very desirable, both from a cosmetic standpoint and for the benefit of her speech, that the sunken ala should be raised. Indeed, the father of the child earnestly solicited an attempt of this nature. Thereupon the writer adopted what proved to be a simple and effectual method of accomplishing the desired end. The metal plate having been fitted, a square platinum bar was soldered to the upper side and bent so that it protruded through the nostril, when it was cut off short enough to be out of sight. The hard rubber intended to plug the aperture in the hard palate was then attached, and with the soft-rubber velum in position the result is seen in Fig. 850, the end of the platinum bar being shown at *a*. The next step was to make a square tube which should telescope over the platinum bar, fitting accurately, so that motion would be prevented. To the end of this tube was soldered a platinum button, so placed that when in position it rested against the inner surface of the sunken ala and lifted it to a proper position. Two views of this tube and button attachment are shown in Fig. 850. In use the instrument is placed in the mouth, the platinum bar passing readily into the nostrils; then the button attachment is slipped over the bar through the external orifice of the nose, the ala being thus distended, and at the same time exerting sufficient pressure to prevent its dislodgement. The fixture is worn with comfort, and the button attachment is tolerated by the nose, the pressure not being sufficient to produce ulceration or absorption. Moreover, while the child's speech, of course, was not immediately improved by the introduction of the palate instrument, the nasal resonance was very markedly lessened instantly by the lifting of the ala. Consequently, it was but a question of time when her speech was rendered normal, which it never would have been with one nostril closed.

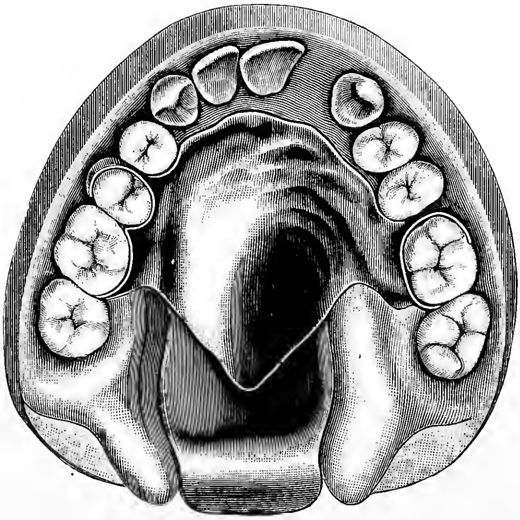
It may be well to emphasize the fact that the mere insertion of an artificial palate cannot be expected to enable the patient to speak correctly, any more than the possession of a piano or violin would make the owner an accomplished musician. The artificial palate, properly constructed, supplies the patient with the means of perfecting his speech, but perfection itself must come through practice. Education by a teacher who thoroughly comprehends the needs of the cleft-palate patient will greatly shorten the time required for improvement, as well as insure a better final result. But the co-operation of the patient is a requisite which is, strangely enough, not always to be counted upon. And it is those persons who have no ambition to help themselves, who have claimed that artificial palates have done nothing for them. An instance of this was noted in a young man at college and approaching manhood who seemed to have no conception of the wretched sound of his speech. An instrument admirably adapted to his needs, and one which undoubtedly made it possible for him to attain perfect speech, was worn by him but three months, and then discarded as of no value to him.

One reason why the artificial palate cannot be expected to enable the patient to speak properly at once is this: with normal organs one

produces articulate sounds by utilizing the normal actions of his throat-muscles and the tongue and lips. With abnormal organs, as with a cleft palate and hare-lip, the individual, in the effort to produce the sounds which he hears from others, compels his tongue, lips, and throat-muscles to adopt habits which are totally dissimilar to normal movements. When, therefore, the artificial palate is inserted, with which perfect speech can be attained only by normal movements, it is evident that the incorrect habits must first be overcome; and, secondly, the correct action of the organs must be acquired. Consequently, those dentists who report that instruments of their devising correct the patients' defective speech instantly, simply report what is not, and cannot be true if the case be of congenital origin.

Since the acquirement of wrong modes of speech must prove so deterring to the patient who essays to improve his speech by resorting to

Fig. 852



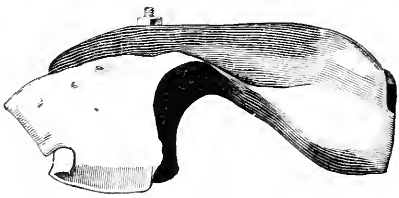
an artificial palate, it is a reasonable corollary that the earlier the instrument is made the less will the patient have to overcome. It is, therefore, both wise and feasible to insert appliances even before the appearance of the permanent teeth. The co-operation of the patient, however, being of such importance, especially where lessons in articulation are to be given—which is always desirable—it is scarcely wise to undertake a case until the little patient is old enough to appreciate the conditions and their remedy. Therefore, except in rare cases where the child is unusually well developed and mentally bright, it is best to wait until the fifth or sixth year.

This statement is introduced at this point because, whatever doubt there may be in older patients as to the choice between the soft velum and the obturator, with children, and especially young children, *the velum is the one and only best dependence.*

An obturator is an instrument designed to merely fill a gap or close an opening in the palate. To be of any service the instrument must be so constructed that it accomplishes all that the artificial velum enables the patient to do, even though in an entirely different manner. It must accurately fill the cleft when the parts are at rest; *it must also fill the fissure whenever and no matter how far the movable sides of the cleft are drawn upward.* To serve such a purpose the obturator must be so thick that when the sides of the palate are drawn upward to their greatest limit they still rest against the sides of the obturator. Moreover, it must be of sufficient length to be reached by the posterior wall of the pharynx, and it must be thick enough at the back end, so that when the pharynx does come into contact with it the closure of the posterior nares will be complete. When using the term "thick," allusion is made to the diameter through the obturator from the oral to the nasal surface, not to the thickness of the rubber, for these obturators are hollow bulbs, and the rubber has but the thickness of a single sheet.

In Fig. 852 is shown a model with an obturator in position. The plate is made of iridio-platinum and the obturator is a hollow bulb of

FIG. 853



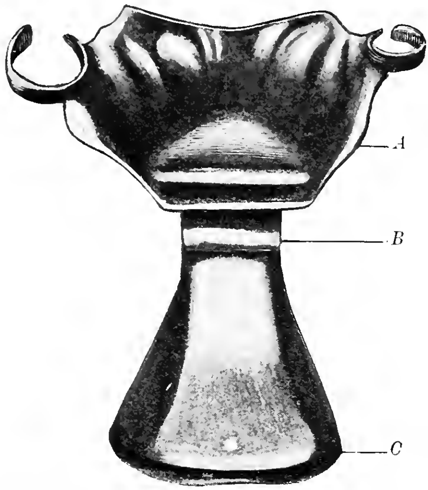
hard rubber. This figure shows the length of the obturator in relation to the uvulæ, as well as the manner in which the oral surface of the instrument fills the gap and completes the arch of the vault. In Fig. 853 the same instrument is shown in profile. It is seen that the rubber bulb is attached to the metal plate by passing over a bar which is soldered to the plate,a nut holding it fast. Thus the bulb may be removed in order to repair or alter clasps or to do anything requiring the operation of soldering, which should be difficult to properly perform were the rubber bulb permanently attached. The figure also shows the thickness of the obturator, which is so shaped that as the divided palate rises contact is preserved. This instrument is a modification of the original Suersen device.

In use, an obturator of this kind, unlike the artificial velum, is stationary in its position, but it is of such form that the pharyngeal muscles of the throat in the movements incidental to the production of articulate sounds hug the obturator, and so separate the cavity of the nose from the cavity of the mouth.

In the *American System of Dentistry* (vol. ii. p. 1068) there is figured a Suersen obturator, modified by the addition of a hinge, for which the following claim is made: "The main advantages of this appliance are—that it is made of a durable material, is easily constructed, and that

articulation can be learned with it more readily than with any other appliance." This claim appears to be based upon the operation of the hinge which unites the obturator with the plate, but this is a misleading device. To the inexperienced it might appear to be an improvement, but in actual practice it will be found to possess no advantage over the Suersen obturator without the hinge.

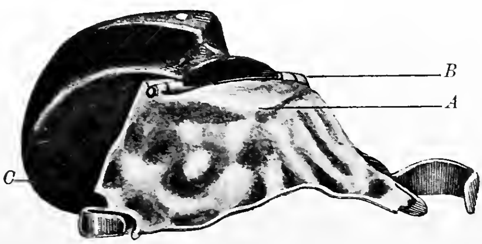
Fig. 854



That the reader may better comprehend the explanation of this fact, illustrations of a hinged obturator have been introduced. Fig. 854 gives a view from the oral aspect, while Fig. 855 shows the upper side. In both figures *A* represents the metal plate, *B* the hinge, and *C* the rubber bulb or obturator.

Unlike the artificial velum, the obturator may be immovable and yet

Fig. 855



serve its purpose, because the soft parts throughout all their varied motions are always in contact with the instrument, the utterance of articulate sounds being thus rendered possible. The addition of the hinge is intended to allow the lifting of the obturator. Even granting that the levator muscles would be powerful enough to accomplish this the question arises, What will be gained? Unfortunately, nothing,

because the same benefits will obtain with an instrument of exactly the same shape, immovably attached. But when further examination of this sort of appliance is made in the mouth, it is readily seen that *the levator muscles do not lift the hinged obturator, but, on the contrary, they raise the sides of the cleft, which slide along the bulb exactly as though it were immovable.*

The original of the instrument shown in Figs. 854 and 855 was made for a patient who for years had been wearing a soft-rubber velum, with which he had learned to speak correctly. This hinged obturator did not rise and fall as it was expected to do, and the patient discarded it and reverted to the velum. Nevertheless, with the hinged instrument this patient talked very well, the reason being that, *having learned to speak with his velum, he could speak with the obturator, and this in spite of the failure of the hinge action.*

One of these appliances was made for a young lady who was assured that she would speak well within a year, but at the end of three years no improvement was noticed. An examination of the appliance in the mouth showed that the levator muscles did not lift the bulb at all, and it was more of an embarrassment than an advantage. Unlike the previous case, where the patient had learned to speak with a soft velum, this hinged instrument was the inital effort made for her relief. Again the hinge failed, and the obturator was practically the same as one constructed without a hinge. But this patient found her appliance of no benefit to her, whereas when she was given the same plate with the same hinge, *but with a soft-rubber velum attached to it,* a course of instruction covering a few weeks enabled her to speak quite well, and she will unquestionably continue to improve until her speech is perfect.

These two cases emphasize the fact, which should be prominently borne in mind, that the soft-rubber velum is the instrument best adapted for correcting the speech of cleft-palate patients; that having learned to speak by using a soft-rubber velum, these persons will do well with a Suersen obturator, with a hinged obturator whether the hinge works or not, and in some cases even with the crude class of instruments designed for no other purpose than to stop the opening in the hard palate.

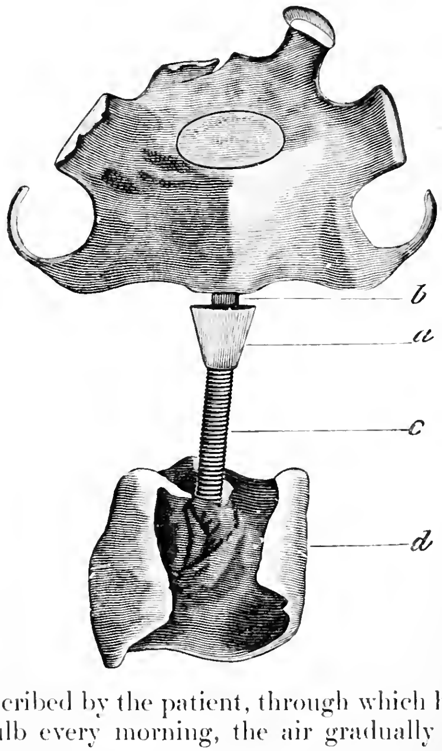
There is but one possible condition where a hinge is needed in connection with a hard-rubber bulb, and that is where a surgical operation has failed, a bridge having been constructed across the centre of the fissure, leaving a cleft posteriorly and a perforation anteriorly. The instrument for which a case may be a hard-rubber bulb which passes through the anterior opening, filling the posterior cleft and reaching to the pharyngeal wall during the act of speaking. Such a bulb is hinged to the plate, and it necessarily rises and falls, because it rests upon the upper side of the surgical bridge, and the levator muscles cannot elevate the halves of the divided palate without raising this bridge and with it the extension which carries the obturator. It is rare that such an anterior opening will permit the passage of the hard bulb, though such cases have been treated. It would be preferable however to sever the

surgical bridge, allowing the cleft to reassume its original condition, than to resort to so complicated a device.

The history of an instructive case which passed through the writer's hands is here given. Before describing this case reference must be made to another sort of obturator which had been employed in this instance. The object in hinging a hard-rubber obturator is to furnish an instrument which will simulate the action of the artificial velum. In Germany the same result had been sought in a different manner. I do not know who claims to be the inventor of the method, but the one which was seen in this case was made by Dr. C. Schultsky of Berlin. This was merely a soft-rubber obturator—in other words, a soft-rubber bulb—hollow like the hard-rubber bulbs, but so fashioned that it could be inflated something after the manner of the pneumatic bicycle tire. The idea evidently is that the soft-rubber ball, placed in the back of the throat, may be compressed by the muscles, thus serving to fill the gap under all circumstances. The history of the patient is as follows: Mr. F——was born in Posen, Germany, in 1861, and was thirty-four years of age when he presented himself for treatment. At birth he had a fissure of the soft palate which reached forward to the border of the hard palate, but did not extend into the bone. Nevertheless, he had a hare-lip, which was operated upon during infancy with but partial success, an opening being left near the nostril. At thirteen Dr. Suersen made for him an obturator having a hard-rubber bulb. This was worn for a year, when the clasp on one side was broken and the fixture was abandoned. At the age of twenty Prof. Wolf of Berlin accepted him as a patient at his private clinic and undertook to close the cleft surgically, and at the same time performed a supplementary operation on the lip. This latter operation was a complete success, and Mr. F——has now a good lip both in appearance and usefulness. A heavy moustache almost completely covers the scar, so that there is no external evidence of his deformity. The operation upon the cleft, however, was another addition to the list of cases where the failure of surgical measures has rendered the dentist's work more complicated, without compensating advantage to the patient. The cleft originally extended to the border of the hard palate, so that it would have been comparatively simple to provide for him an artificial velum similar to that shown in Figs. 848 and 849. After learning to speak he could then have had an obturator should he have desired it. The operation, however, by partly closing the cleft constructed a bridge of soft tissue over which a plate could not be worn, so that it became necessary to have an extension to the plate which should carry the appliance used to fill the gap. Thus the patient was very much worse off after, than before his operation. A year later he placed himself under the care of a dentist, Dr. C. Schultsky of Berlin, who made for him a soft-rubber obturator. All that remains of this instrument is shown in Fig. 856. This consists of a vulcanite plate clasped to the natural teeth and carrying a few artificial teeth. Immediately at the posterior border is a small extension (*a*), also of vulcanite, which is connected with the plate proper by a

gold slide (*b*) which moves forward and backward in a metal slot, thus providing for antero-posterior movement. Next there is a gold spiral spring (*c*), which permits the obturator to follow the play of the muscles in any direction. At the posterior end of the gold spring was permanently fastened a soft-rubber bulb or ball (*d*). Judging from what was left of this bulb, it may be inferred that originally it was quite thick along that portion which formed the palatal surface and was intended to complete the arch of the vault. Into this thick portion the spring was fastened. Thinner walls extended upward, completing the bulb and leaving it hollow. There was some sort of orifice and stop-valve,

Fig. 856

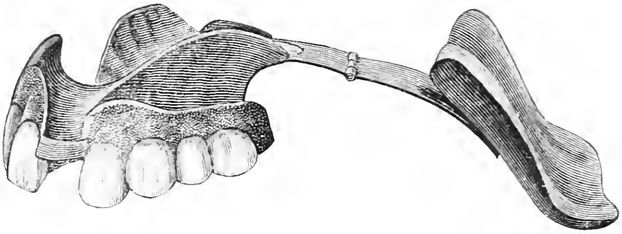


inadequately described by the patient, through which he was instructed to inflate the bulb every morning, the air gradually escaping during the day.

He wore this instrument for five years; during this time, however, the bulb burst, whereupon he continued to wear it in its ruptured condition. Then he had a second bulb attached by the same dentist, which after a brief time also burst. Nevertheless, he continued to use this appliance for eight years more, and the figure shows the fixture as I found it. Two facts in connection with this case are peculiarly instructive: so long as the original bulb remained whole there was no improvement in the patient's speech; second, after it had burst he noticed a very rapid change, and within two years he was speaking with approximate correctness. Thus the ruptured bulb was better than the

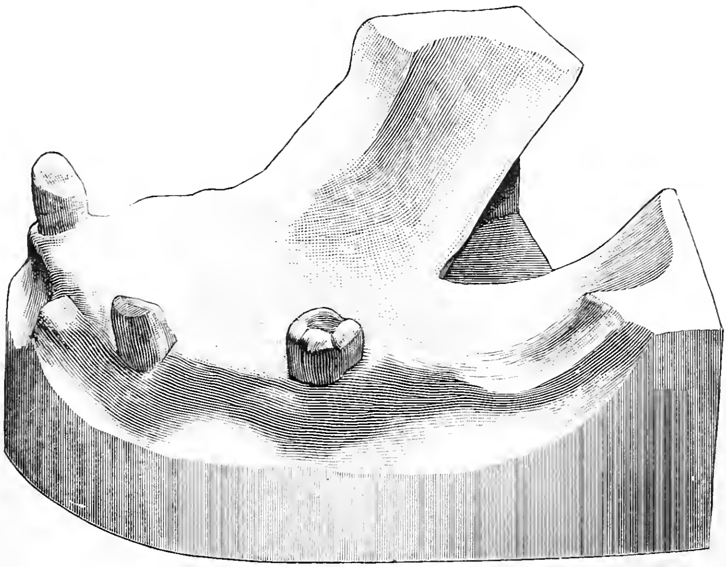
soft-rubber obturator which it was intended to be; and the point of great interest here is that, though in a very crude way, still in principle, *the bulb became a Kingsley soft velum as soon as it was ruptured.* This can be better comprehended by comparing Fig. 856 (Dr. Schultsky's instrument with bulb ruptured) with Fig. 857 (which shows the appli-

Fig. 857



ance constructed for him by the writer). It will be seen at a glance that the velum here appears to differ from the typical form shown in Figs. 845–847 in the fact that there is but a single flap. It is therefore necessary to explain how it is that the principle is the same though the form is different. The typical velum has two flaps, one of which

Fig. 858

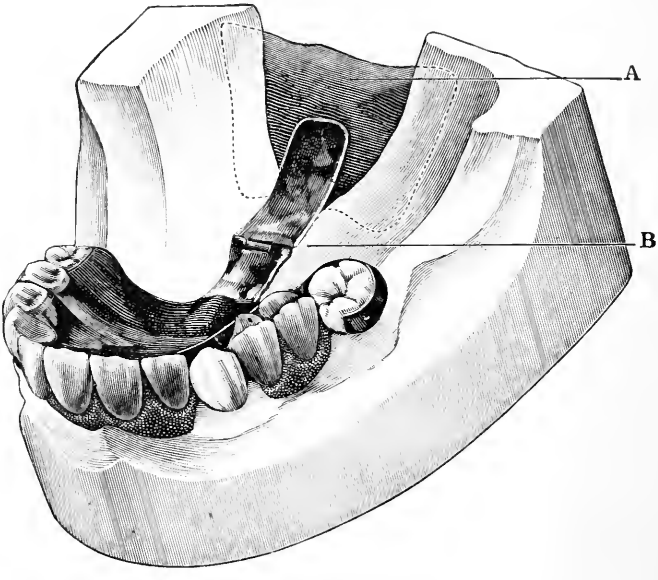


lies in the upper cavity resting upon the sides of the cleft, while the lower flap is below, the two forming grooves in which the sides of the cleft move. When closed, the uvulæ, or extreme posterior ends of the split velum, approximate one another, hugging the artificial velum closely.

Fig. 858 shows a model of a mouth, and the absence of the uvulæ

will be observed. The uvulæ were originally present, but were destroyed by the surgical operation, and the sides of the cleft posteriorly are now continuous with the pillars of the fauces. Here, therefore, there was no need for grooves, there being no possibility of the close approach of the sides of the cleft. A single flap was made, such as is shown in Fig. 857. The anterior edges were made heavier than usual, to offer sufficient resistance to ensure the raising of the hinge extension which connected the velum with the plate in the roof of the mouth. The single flap is similar in the theory of its office to the single flap of Dr. Sercombe, but modified to assume the more practical form seen in the upper flap of the Kingsley velum. Dr. Sercombe claimed that the

Fig. 859



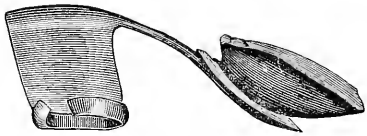
flap should not reach the posterior wall of the pharynx; in this he made a grave error.

Here, then, may be indicated the reason why the hinge is of no value with an obturator, and yet becomes a necessity with such a case as the last two—viz. where the apex of the fissure is distant from the posterior border of the hard palate. Obturators are constructed of hard rubber, have sloping sides, and are highly polished. In the efforts to close the cavity of the nares the levator muscles draw the sides of the cleft upward and slightly backward, and if a patient can be made to swallow with the mouth open, the operator will readily discover that *the tissues slide along the smooth sides of the obturator, but do not raise it.* The hinge, therefore, is useless. With the other condition a totally different result obtains. The soft velum, lying entirely upon the upper surface of the cleft, and the anterior edge of the velum being stiff and wide, while the apex of the fissure presents the usual angle, it follows that *the*

natural palate cannot rise without carrying the superincumbent velum with it. This it could not accomplish if the extension which connects the velum with the plate were unyielding. Consequently, the hinge is a positive necessity. Fig. 859 is the same as Fig. 858 with appliance in position, the dotted line indicating the border of the velum, which is above the fissured sides of the palate, and making it clear that no movement can displace it, while the least retraction of the tissues must be followed by a responsive movement of the velum and the hinged extension. In the figure the velum is seen at *A* and the hinge at *B*. The plate in this instance was made of vulcanite to suit the wishes of the patient, his original plate having been of that material. Metal would have been preferable.

Fig. 860 is of special interest: it shows a similar instrument having a hinged extension, but the soft velum is of the typical form, because, although there was a great space between the border of the hard palate and the apex of the fissure, thus necessitating the hinged extension, nevertheless the fissure itself was fairly regular, the uvulæ being pres-

Fig. 860



ent, and the two sides of the cleft when shutting off the cavity of the nares working co-ordinately. The model of this case is seen in Fig. 863, while the instrument with tiny velum is shown in Fig. 860. In connection with hinged artificial palates it is also of interest to record the fact that this case was treated by Dr. Kingsley some thirty-five years ago.

I have elsewhere stated that it is but rarely advisable to attempt mechanical assistance earlier than the fifth or sixth year. Indeed at the time when that statement was written I had known of but two instruments made for very young children. One was in the case of a girl of six. Surgical interference had left a slight aperture along the median line, anteriorly, while the union of the soft parts promised to be adequately satisfactory. For this patient Dr. Kingsley made a tiny carrying plate to cross and cover the forward aperture, which was completely occluded with a hard rubber attachment on the upper side of the carrying plate.

The idea was, that by closing this orifice, and with proper training the child's speech might improve, and this anticipation proved well founded. It is of interest to record, however, that later a retrogression

occurred and then, some years after it was seen that with her growth the child actually developed a cleft palate. The sides of the united palate grew, while the cicatricial tissue along the line of union acted as a barrier to development in that region, the result being that at twelve years of age a well defined cleft was present, and Dr. Kingsley was compelled to insert a regular instrument carrying a soft velum.

In another case he made a soft velum instrument for a girl of seven or eight, but it has been my pleasure to have pass through my hands an interesting little subject aged only four for whom a velum instrument has been successfully, and I think advantageously supplied. By this I mean that the result already seems to prove that it was better to supply the instrument early, rather than to wait, and this in spite of the fact that the child has had no instruction except such as could be given by

Fig. 861

its mother. Yet now, at the age of five she attends a kindergarten and can make herself understood by her playmates, whose companionship before she had shunned.

This child was sent to me by a surgeon who had already twice operated unsuccessfully. Indeed the attempts but left the mouth in a worse condition. The illustration (Fig. 861) shows the original cleft partly closed, but an ugly mass of scar tissue now occupies the forward part of the original cleft, and the edges are so thick that, though what may be called a Kingsley velum was made for the case, its appearance is quite unlike the usual form (Fig. 862).

Allusion has been made to a new artificial palate, or velum obturator, the invention of Dr. Calvin S. Case. The following is Dr. Case's description of his instrument.

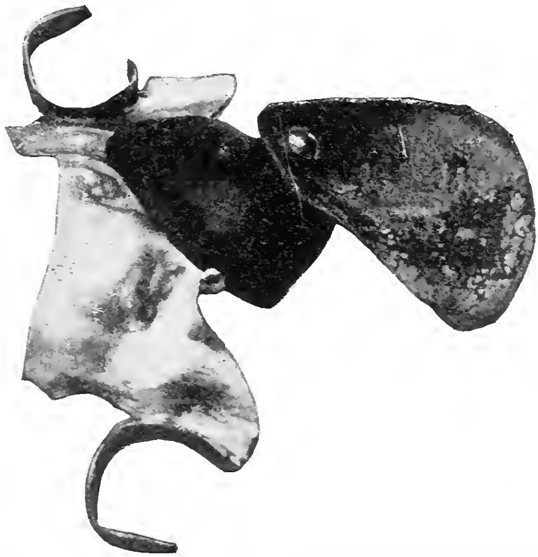
"Through a desire to take advantage of the benefits afforded by a soft-

rubber appliance on the one hand, and a hard-rubber obturator on the other, and at the same time avoid the possibilities of the final inefficiency of the one and the difficulties in construction and adjustment presented by the other, has risen the present artifiical palate, which it is the object of this paper to present.

It essentially consists of a form of palate which can first be made of soft rubber and possess all the advantages of the Kingsley velum, and then when the patient has become accustomed to it in its flexible state, and its form is an assured success by packing the same casts in which the soft rubber palates were vulcanized with another quality of rubber, a hard-rubber palate is produced which possesses all the advantages of a perfect obturator.

If made of softer rubber the first palate can be worn without irritation or special inconvenience; after which, desired changes in its form, that

Fig. 862



are nearly always required to perfect the palate, can then be easily made by slightly enlarging or contracting the metal mold in which it is vulcanized.

Those who are familiar with the Kingsley palates, which I am pleased to say I have used with great satisfaction in my practice for over twenty years, will remember that the veil or posterior portion of the palate is sustained by extending the central thickened portion into it, and from this point it is gradually flattened to a comparatively thin edge, where it is more or less curved in conformity to pharyngeal wall, against which it is intended to rest during the contracion of the pharyngeal and the palatal muscles.

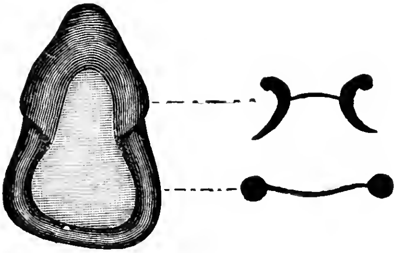
In this particular it is quite different in form from the palate I am about to describe, in that with the latter all the central portion of the palate is thin, while the edge of the veil is thick, in the form of a

solid roll about one-fifth of an inch in diameter, or preferably triangular, with rounded corners, so that its outer flattened surfaces exactly and firmly fit the pharyngeal walls *when the muscles are in a contracted state.*

Fig. 863 represents the pálatal view of the artificial palate, with transverse section. Fig. 864 shows transverse sections through the mesial plane. Figs. 865 and 866 show the palate in position.

In extensive clefts the borders of the veil extend forward along the lateral walls of the pharynx and posterior nares, and, becoming thinner, form the borders of the nasal extensions which rest upon the floor of the nares.

Fig. 863



When the cleft does not extend into the hard palate, the veil is shaped in a similar manner, but with the nasal portion abridged to meet the requirements of the case.

Where the cleft extends into the hard parts, the body of the palate which covers the borders of the cleft and forms the lateral wings on the roof of the mouth should not extend back of the attachments of the bifurcated velum palati, nor in any way interfere with the free action of the muscles ; neither should it extend upon the roof of the mouth any farther than is necessary to give a firm seating for the palate. This portion should be about as thick as an ordinary rubber plate, being thinned along its oral borders and thickened to form the nasal borders.

Fig. 864

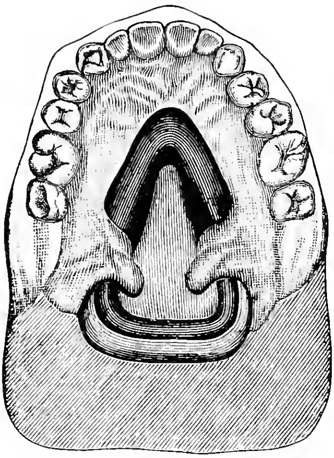
There are a number of important advantages in this form of palate, even when made of flexible rubber and used for the purposes of a velum :

First. The early deterioration of the rubber, causing the curling up of thin edges of the vell, is entirely prevented. When this occurs, as it frequently does with ordinary vela, the vocal usefulness of the palate is impaired—if not destroyed—in proportion as it permits the escape of air at the curled-up portion of the border,

Second. The heavy border of the veil is sufficiently yielding and flexible to be worn with comfort if properly fitted, and its also presents

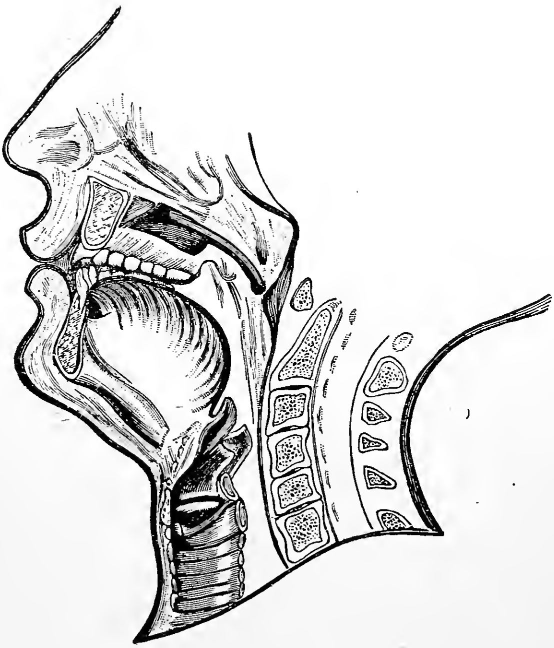
sufficient stability and breadth of surface to permit firm contact of the pharyngeal muscles in closing the naso-pharyngeal opening.

Fig. 865



Third. In more or less extensive clefts the thin central portion extending forward into the body of the palate permits a resilient yielding of the lateral portions of the body, which frequently allows one to

Fig. 866

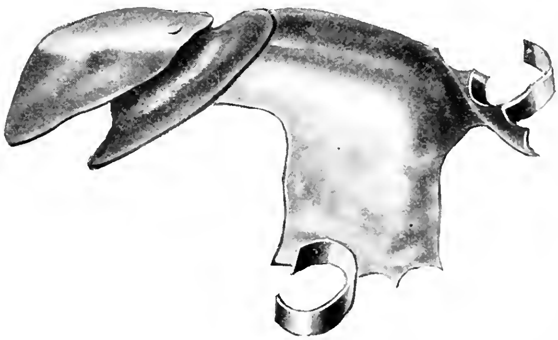


spring it into place with sufficient grasp of the irregular borders, along which it should accurately fit, to hold it in position without the aid

of supporting plate. Whenever this can be accomplished with the soft palate, it will readily be continued when it becomes hard."

In 1902 I constructed a new form of instrument which apparently falls under the term, "velum-obturator" in that it has the compound action of both. A patient came into my hands for a new instrument, the one made for her by Dr. Kingsley some ten years previously having lost its usefulness. I had known the lady when her first instrument was made, and was well aware of the improvement it had made in her speech. I was not prepared, however, for the curious condition which I found had resulted from its use. The velum had fitted perfectly when first adjusted, the palatal flaps spanning the gap and resting lightly against the split soft palate, while the nasal flap rested above and extended posteriorly in such a way that the sides of the divided palate, when brought into action, would slide between the flaps, and throw the posterior flap upward, its thin edges turning upward to occlude the passage of the nares, this, of course, being the intended object of the Kingsley velum. (See Fig. 848.) An examination, however, disclosed the fact that the in-

Fig. 867



strument was not so operating. The muscles of the pharynx had so increased in activity that in the closure of the throat their contraction would entirely extrude the soft-rubber velum, so that the nasal flap lay constantly toward the palatal side of the fissure, and therefore became merely a useless mass of rubber which served no practical purpose.

In this dilemma I conceived the idea of constructing an instrument, the nasal flap of which should be just the reverse of the Kingsley appliance. Instead of forming the nasal flap with thin tapered edges, slightly turned upward (see Figs. 845, 846, 847, 849, and 850), so that in the closing of the throat these edges would be everted, thus presenting a broad surface contact to the walls of the pharynx, I undertook to fashion a soft-rubber appliance with a posterior or nasal flap, having its most posterior surface so formed that when the pharyngeal muscles should close upon it, there would be broad and equal surface contact, thus effectually occluding the passage to the nares, and so obviating the escape of sounds in that direction.

Fig. 867 shows the first instrument of this character made by me.

Comparison of this illustration with Fig. 849 will show that the nasal flap of my instrument is exactly the reverse of that in Dr. Kingsley's. In the Kingsley appliance the throat muscles must evert the thin edges of the velum, and so produce contact and occlusion of the nasal passages, while in my instrument the soft-rubber nasal flap is of just such size and shape that, remaining quiescent, the pharyngeal walls in closing come into accurate contact with it. Being made of elastic material, any increased activity of the throat muscles will be compensated for by the fact that the appliance is pliable, and in this respect closely resembles the natural organs as they are when normal.

It will be seen at once that the success of such an appliance must depend upon obtaining a model of the parts which will represent the anterior part of the mouth, and the region of the divided palate, *as they are when absolutely quiescent*, while at the same time the back part of the model should give us the *exact form and relative positions of the pharyngeal muscles when endeavoring to close the throat.* In this act there is left an irregular opening, which is never symmetrical, at least in every case that I have observed one muscle appears to be more energetic than its fellow of the opposite side, and it is to this irregular opening that the posterior surface of the nasal flap must be made to conform, so that the throat in closing will grasp it uniformly. The method of obtaining such a model will be found described in the directions for taking impressions and making models.

This first velum-obturator made by me encouraged me to believe that by chance I had stumbled upon an idea of value, because immediately upon its introduction all nasal resonance disappeared and articulation was restored. This statement, however, must be qualified. I have heard many men, describing success with their first attempts at treatment of cleft palate, declare that the patient could speak perfectly as soon as the instrument was introduced. Such statements should be received with great scepticism, as I have never seen such a result either with my own or with Dr. Kingsley's patients. In this particular case, however, we are discussing a patient who had worn an artificial palate for ten years, and who had learned to talk almost perfectly with it. Then, with the increased activity of the pharynx, and consequent displacement of the apparatus, the woman's speech had retrograded and the nasal resonance had almost entirely recurred. It needed, therefore, but the introduction of an appliance which could be kept in place in spite of the great activity of the throat muscles to restore the quality of her speaking voice.

It may be well here to explain more clearly what I mean by the "activity" of the throat muscles, and perhaps I can best do so by stating that with the new appliance in place, and all the tissues at rest, if one looked down into the pharynx, the velum-obturator would appear to be very much too small, a space equal to the diameter of a lead pencil existing between the nasal flap and the sides of the split palate. Yet if with a syringe drops of water were allowed to trickle into the throat, compelling the act of swallowing (with the mouth open for observation),

the palate and pharynx would be seen to contract and firmly grasp the posterior flap.

This instrument has been worn by this patient ever since with such satisfaction that all instruments made by me since 1902 have been made of this form.

TAKING THE IMPRESSION OF CLEFT PALATE.

No appliance made by the dentist needs to be more accurately fitted than an artificial palate. It is obviously a corollary, therefore, that the plaster model should be as nearly as possible an exact reproduction of the mouth which it represents.

To obtain such a model requires skill, but not more than should be possessed by the qualified practitioner. Yet the difficulty of taking the impression is the obstacle which has hindered many from attempting to treat these cases, while the ultimate failure of many others who have essayed to make instruments is directly traceable to their inaccuracy in this initial step.

The ordinary impression taken for artificial dentures is easy, because a model is required only of that portion of the mouth, the tissues of which overlie bone. Therefore, whether the impression material be introduced hot or cold, hard or soft, in large or small quantity, the resultant impression is approximately the same, because of the resistance offered by the roof of the mouth against which it is pressed. When, however, too much material is carried into the mouth, so that it extends beyond the border of the hard palate, the common experience is what is called "gagging." A consideration of what this "gagging" is, will make more readily understood a fundamental principle involved in all cleft-palate cases.

The soft palate is sensitive, and when the impression material is brought into contact with it, the result is an irritation or tickling, whereupon the involuntary muscles of the throat endeavor to draw the parts away from the intruding substance. Thus the velum is elevated, and consequently were a model to be made from such an impression it would be inaccurate as to the posterior portion of the mouth, in that it would not be a representation of the parts at rest.

With the velum divided as in cleft palate, the disturbance of these sensitive tissues upon the introduction of the impression material is even greater. The two halves of the soft palate are not only drawn upward, but they also approach each other. Thus the resultant model will show the cleft *narrower than it really is when the parts are at rest, and the pose of the divided palate will be wrong,* so that no proper calculation can be made for restoring the true arch of the vault. This will obtain whether the impression be taken with plaster of Paris, or with impression compound softened by heat. Where the impression compound, however, is not very soft, or where the divided palate is lacking in vital response, the impression material will merely press the soft tissues before it, the final model being absolutely worthless.

Thus it is seen that no one can obtain an absolutely accurate *im-*

pression of the divided velum *in its normal pose*. Nevertheless, a *model* may be made which will be as accurate as any model of the mouth can be.

The method of procedure is as follows: select an impression tray of the ordinary form, just large enough to embrace the arch without stretching the mouth, and long enough to reach slightly beyond the posterior border of the hard palate. In the majority of cases this will answer all purposes, but occasionally, it may be advantageous to extend the cup by adding to it a flap of sheet gutta-percha. This may be carried back as far as the uvula, but should not touch the velum at any point. This is to be ascertained by introducing the cup empty.

Plaster of Paris is mixed in the usual way, a little salt being added to hasten the setting, and warm water used to render it more acceptable to the mouth. A pinch of powdered vermilion will color the impression which will aid in separating, and is preferable to placing the color in the plaster for the model. The plaster is placed in the tray in quantity proportionate to the height of the roof, less being used where the cleft is in the velum only, than where the fissure enters the hard palate also. The use of too much plaster is to be avoided, lest it escape and trickle down the throat. The impression tray is to be carried into the mouth just as the plaster gives evidence of setting, and is pressed up quickly and firmly, and then held steadily until sufficiently hard for removal. With a little practice the calculation can be made with such nicety that the time required will be not more than one minute. The plaster which remains in the vessel in which it was prepared will be a guide to its setting, and as soon as it will fracture sharply the impression should be withdrawn.

Where the fissure extends into the hard palate it will occasionally occur that the plaster which passes up into the nasal cavity cannot be withdrawn with the impression; but if the impression be removed at the proper moment, the plaster will fracture along the line of the fissure, and that portion left up in the nares may be taken away with the tweezers.

Before passing to a consideration of constructing the model one or two other points in relation to the impression are to be considered.

Ordinarily, all that is required in a model from which to make an instrument for a cleft-palate patient will be absolute accuracy as to the oral aspect of the parts and the borders of the fissure from its apex to the uvulæ. It will very rarely be essential to procure a perfect impression of the upper or nasal side, except that the operator should observe the thickness of the tissues along the borders of the cleft, the position of the vomer, and whether it is likely to interfere with the design of the instrument, as it often will where the fissure only slightly enters the hard palate. In such cases it becomes important to know how close the insertion of the vomer is to the border of the cleft at the apex. This is readily accomplished by placing a small quantity of plaster up into the nasal cavity at the apex of the fissure, carrying it into place with a narrow-bladed knife, or other suitable instrument, just before introducing the impression. This may come away with the impression, or

it may fracture and remain in place, in which case it is to be removed with tweezers and added to the impression.

Where the fissure partly enters the hard palate, as has been already stated, the exact position of the vomer must be comprehended. The reason is that where an artificial velum is used, it engages the fissure, so that a flap extends slightly over the border at the apex on the nasal side. In some cases the insertion of the vomer into the hard palate is so near to the border at the apex that the artificial velum might rest against it and cause irritation, unless provision be made to guard against this. But the simple method of carrying a little plaster through the fissure at this point before inserting the impression, as previously described, accomplishes the required result perfectly.

Where the fissure involves the whole or greater part of the hard palate it may occasionally be required to secure an accurate model of the nasal cavity as well as of the oral.

The impression here is obtained by carrying the plaster, mixed fairly stiff, up into the nasal cavity, filling it to the borders of the fissure, whereupon the tray with additional plaster is carried to place. As the plaster in the tray unites with that which is in the nares, great care must be observed to remove the impression at the first moment, when a sharp fracture is possible. With a sudden sharp movement the impression comes away, leaving the plaster in the nares, the fracture along the borders of the fissure being sharp and clean, so that, when the nasal portion is removed by sliding it back toward the throat and allowing it to drop down upon the tongue, it is readily replaced in proper position upon the impression. If the operator is timid about attempting this, after filling the nares with plaster he may allow it to set. Then after oiling the exposed portion of the plaster, which now finishes out the arch of the roof, the impression may be completed without danger of the two parts adhering. For the purpose of obtaining an accurate impression of the margins of the fissure, the late Prof. George T. Barker recommended the use of a piece of soft sponge cut to approximate the size of the fissure, first having been made pliable by immersion in warm water, wrung out, and then saturated with plaster of Paris mixed thin. The sponge so prepared is then quickly carried into the fissure and allowed to remain until the plaster has fully hardened, when it can be readily removed without force by means of suitable tweezers. The portion corresponding to the roof of the mouth may then be trimmed smooth, varnished, oiled, and replaced. The impression with the cup may then be completed without injury to the delicate edges of the fissure.

It will we well for those who wish to utilize Dr. Case's appliance to follow his own mode of taking his impression, which he describes as follows ;

" In taking an impression for the construction of this palate where the cleft is extensive or even extending somewhat into the hard palate, it is my object to obtain a perfect model of that portion of the roof of the mouth over which I wish the palatal portion of the plate to extend, and along the borders of the cleft forward of the pendent portions of

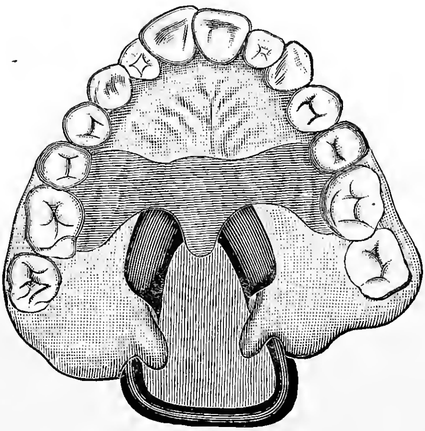
the velum palati, extending somewhat upon the floor of the nares and representing as perfectly as possible the nasal borders of the cleft and lateral surfaces of the posterior nares.

These surfaces, a part of which lie above the pendent and unstable tissues of the velum palati, are frequently susceptible of being perfectly reproduced in the model of a plaster impression. It will usually be found in a typical case that the posterior nasal openings are laterally constricted, from which point the nasal fossæ widen to form the floor of the nares. By obtaining a perfect impression of these somewhat unyielding surfaces, which otherwise, on account of their position, would be very difficult to reproduce, the anterior borders of the artificial veil can be perfectly fitted to them as they merge into the nasal borders of the body.

I lay particular stress upon this portion of the operation because I have found it important, not only as a great aid to the proper action of the pharyngeal muscles, but in clefts of considerable extent the overhanging nasal borders of the artificial palate can be easily sprung into place, and when fitted perfectly patients soon learn to place and sustain the palate without the aid of a supporting plate.

I would advise, however, that the supporting plate be always made, to enable patients to more readily adjust and sustain the plates until they have learned to wholly do without it.

Fig. 868.



When no artificial teeth are required, or when, if required, a bridge denture is practicable, the supporting plate should be made to cover as small an area of the roof of the mouth as is consistent with the demand for strength, I rarely extend it forward of the second bicuspid, leaving as much of the anterior palatal surface exposed as possible, which I believe materially aids in acquiring perfect enunciation.

Fig. 868, which is made from the model of an impression of the

mouth with the apparatus in place, shows the form of the supporting plate I usually make.

There are two ways of taking these impressions: One by forming a base of modelling compound upon which to lay the plaster, and the other by using plaster alone.

For the first the compound is wrapped around the forefinger (Fig. 869), and pressed gently to place. Removing, softening, and perhaps slightly reshaping and cutting away surplus, this is repeated several times, with the view of finally obtaining a modelling compound impres-

Fig. 869

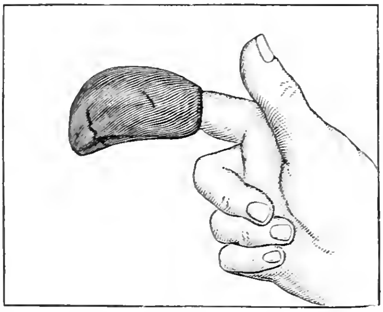


Fig. 870

sion that will not displace the soft posterior borders, and that will perfectly support the plaster for the final impression. (Fig. 870.)

The palatal surface is then roughened so the plaster will cling to it, and all that portion of the compound which extends above the nearest approaching borders of the cleft is cut away and the cut surface smoothed and oiled. (Fig. 871.)

This, when carried to place with the plaster in position, need cause

Fig. 871

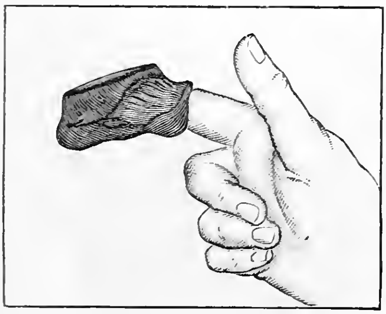


Fig. 872

no fear of its easy removal, even though an excess of plaster is used—providing it does not come forward of the alveolar ridge in extensive double clefts—as all that portion which extends above the border of the cleft forming the impression of the nasal fossæ will readily break from the smooth, oiled surface of the compound, when the impression is removed, it being otherwise unattached to the lower parts, as the com-

pound completely bridges the cleft from its nearest approaching borders. The nasal section can then be teased back toward the more open portion of the cleft, and allowed to fall on a mouth mirror, from

FIG. 873

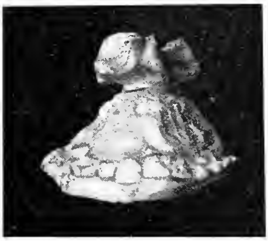
FIG. 874

which it is replaced upon the impression. (Fig. 872.) Figs. 873–875 show different views of a plaster impression taken this way.

As a rule, I prefer plaster alone, dividing it as above in sections at the borders of the cleft. Figs. 876–878 show different views of an impression

FIG. 875

FIG. 876



of a cleft taken entirely with plaster. The first section is passed freely into the nasal cavity with a spatula, stopping it abruptly at the nearest approaching border of the cleft. The under surface is then lubricated with a solution of white vaseline, and the first part of the second

FIG. 877

FIG. 878

section is delicately laid on with the spatula, so as to not lift or dislodge the upper section. The plaster is spread out over the roof of the mouth with a spatula, and when partially hard is strengthened for

removal with fresh plaster introduced in a flat impression tray. The impression does not need to extend even to the gingival borders of the teeth.

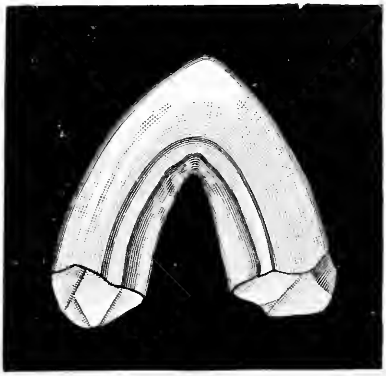
In filling and trimming the casts from these impressions, nearly all that portion back of the attachments of the soft palate is cut away, and the nasal portion of the cast open and freely exposed to the extreme nasal borders, produced by the impression.

This is done to facilitate shaping the modeling compound model or pattern of the palate, and its ready removal from and replacing upon the cast during the process of repeated trials in the mouth.

Fig. 879 shows palatal view of the finished model. The nasal view would look very similar."

In cases where there has been an operation upon the lip the mouth will sometimes be so contracted as to preclude the possibility of introducing a full impression tray, one that would extend over and include the teeth. Usually, however, a tray may be introduced if cut away so as just to cover the occlusal surfaces of the teeth, the removal of the outer rim allowing its introduction with less stretching of the mouth. An impression thus procured will give a model showing the roof of the mouth and the cleft, the palatal surfaces of the teeth and part of their occlusal surfaces. In order to perfect such a model the correct shape, forms and positions of the teeth, may be secured in the following manner. A second impression is taken of one-half of the upper jaw

Fig. 879



using an ordinary crown- and bridge-work tray. Care should be observed to include if possible the central incisors. From the original model the greater portion of each plaster tooth is cut off, and the outer part of the model roughened with a knife. The new impression is now fitted to the model, and will be found accurately adapted, and it may be held fast with sticky wax. New plaster is poured into the impression and against the model. When this has hardened the impression is removed, and the model will be found complete on one side. A similar procedure will complete the model on the other side, and the precaution of securing both centrals will be found an aid in placing this

last impression in position. Fig. 880 is from a model thus made, and the plate made from this model accurately fitted the mouth.

In accidental fissures resulting from disease or other cause we sometimes find merely an aperture in the palate, which may be quite small. In taking an impression the plaster would ooze through this hole and form a knob or button upon the upper side, which, of course, would remain after the removal of the impression-cup. Then, as the posterior portion of the soft palate would be normal, it might become a very difficult matter to remove this plaster without permitting it to pass down into the pharynx. In these cases the precaution should be taken to lay across the aperture a bit of Japanese tissue-paper folded two or three times. This paper will yield sufficiently to allow the plaster to take a perfect impression, yet resist its passage through.

Where the ravages of disease may have been very extensive, a case may present in which the palatal separation of the nasal and oral cavities may be entirely absent, and the two being practically one, occasionally irregularities and convolutions present which make it desir-

Fig. 880

able to proceed without first procuring a complete model of the parts. The procedure is as follows: A sheet of gutta-percha is softened and trimmed to approximately cover, let us say, the right half of the cavity extending below, over the alveolar ridge, or teeth, if these organs be present. Using this as a tray an impression of the right half is easily procured, and a model made. On this model a wax plate is fashioned and reproduced in vulcanized rubber. This rubber plate is tried in the

mouth, and any angles that might cause irritation or render removal difficult are carefully filed away, until the plate rests comfortably against the right half. With this in place, plaster is then pressed against the left side and partly over the rubber plate. When hard the two are removed separately, waxed together, and a model made over them both. A plate of vulcanite is now made for the left side, both being united in the vulcanization, so that we now have a shell of thin vulcanite rubber which will fit the whole interior of the cavity. This is next filled with plaster carved so as to form a representation of a normal vault when in place. With this surface oiled to prevent adhesion of new plaster, the shell with its filling of plaster is placed in the mouth and an impression taken as of a normal mouth. The model from this will have the shell of vulcanite in place, and still retaining the filling of plaster. Using this as any regular model, a set of teeth (if teeth be required) is made, and in the course of vulcanization this final rubber plate attaches to the shell which lines the upper cavity. On removal from the flask a hole is cut opposite the nostrils, and another at the back, and through these holes the plaster filling is dug out, leaving a set of teeth, having a hollow superstructure of vulcanite which closely fits against all the upper surfaces. A plate of this character usually stays in place quite fixedly. The two holes supply breathing apertures.

PERFECTING THE MODEL.

The model made from the most accurate impression will represent the cleft with its sides drawn somewhat together and possibly pressed backward. The next step, therefore, will be the correction of these errors, and the production finally of a model which will be an accurate reproduction of the mouth.

When the chapter for the first edition of this work was written it was my opinion that after obtaining the model from the impression, the further correction of the same might be confined to the outline of the borders of the cleft, but the necessities of three or four extreme cases which have passed through my hands since that time have materially altered my views on this subject.

First, however, I may describe how the proper shape and outline of the cleft itself is to be obtained. A trial plate is made of gutta-percha, and as it must be quite stiff to adequately serve, it is best to use two sheets. The first sheet may be fitted to the model as it stands after removal from the original impression. An extension of this trial plate is trimmed to just lie within the cleft as it appears, or within as much of it as is shown; sometimes only a part of the fissure is disclosed in the first model. A second piece of gutta percha of similar pattern is cut, to be warmed and pressed into place over the first; before doing so, however, a piece of copper or tinned iron wire is formed into a loop and pressed into the first layer of gutta-percha, the loop running down into the extension which fits into the cleft. The second layer of gutta-percha

is then placed over the first, and this, with the wire loop between, furnishes a stiff trial plate, which may, however, be bent as desired. If this be tried in the mouth, two facts at once appear. The natural cleft will be seen to be wider than that in the plaster model, as indicated by the width of the trial plate extension. Second, the sides of the natural cleft now fall down much below the gutta-percha extension, proving, as elsewhere claimed, that the divided palate is drawn up during the intrusion of the plaster impression. The tail piece is, therefore, bent down until it exactly follows the true curve of the natural palate, when the two halves are at rest, and it will occasionally take some patience to ascertain this, as the sensitive sides of the cleft palate will often flutter for a very long time before coming to rest. But with persistency in keeping the mouth open, the muscles finally tire and remain at rest. Next wax must be added to the sides of the tail piece and repeatedly tried in the mouth, until it is seen that the tail piece is so shaped that when at rest the divided palate just touches it at all parts. This then furnishes an accurate guide to the exact shape and curve of the natural palate. This is placed on the model, when it will be found necessary to cut away the plaster along the edges of the cleft, until the extra width of the re-modeled tail piece drops into place. The edges of the plaster model are next built up to the gutta-percha guide with plaster carried on a camel's hair pencil. The plaster should be extremely thin, and the model wet, else it will be difficult to work. In this manner the sides of the cleft, and even the divided uvula, may be quite accurately reproduced.

A model of this character will suffice, where an obturator is to be supplied, for as will be seen elsewhere, further impressions of the pharyngeal portion become a part of the technique of procuring the model for the obturator. Moreover I had until recently thought that such a model would suffice where a velum is to be made, because ordinarily the velum may be made sufficiently small so that at first it is readily tolerated, and it is no difficult matter to alter the molds so as to lengthen or widen the velum subsequently, as may be seen to be required.

But cases have passed through my hands where the activity of the muscles was so great that in the act of swallowing the pharyngeal muscles approach each other to such an extent as to almost occlude the nares. In such cases it becomes absolutely requisite to obtain a perfect model of the pharynx, not in its normal state of rest, *but as it appears when closed, as in the act of swallowing,* for it is manifest that the size and shape of any instrument inserted in such a throat must largely be regulated by the position of the muscles when thus drawn towards one another, as well as by the aperture that may be left.

We aim then to obtain a model which will show all the mouth parts as they are when in a normal state of rest, while the pharyngeal portion must be seen in the same model as it appears when contracted as in the act of swallowing. Occasionally it may be requisite to proceed as in making an obturator, and at this point make the platinum carrying plate. This necessity will only arise when the patient finds it difficult

to swallow while the operator holds one finger in the mouth to steady the trial plate.

The tail-piece of the trial plate is extended until it nearly, but not quite, touches the posterior wall of the pharynx. A bit of sheet wax is then added to the extremity and turned upward; this will be better comprehended when it is explained that it is to serve to prevent the passage of plaster down the throat. Along the upper side of the tail piece other pieces of wax are added to form a sort of box, to hold plaster. This is then tried in the mouth and the patient made to swallow, until the operator is satisfied that his added wax in no way hinders this action. Plaster, with very little salt, is then mixed quite thin and piled up on top of the tail piece which is then quickly, and skilfully adjusted, care being observed not to spill the plaster into the throat, thus producing gagging. The patient is then made to swallow forcibly two or three times, and then asked to remain as quiet as possible. As soon as the plaster hardens the trial plate (see Fig. 893) is removed, and is then placed in position on the model. I may say here parenthetically that when from the extreme activity of the throat muscles the operator decides that this procedure will be required, it is best to take this step prior to perfecting and completing the shaping of the borders of the cleft. The plaster used to take this impression of the contracted pharynx should have some coloring matter (powdered water color paint added to the water) in order to facilitate separation, and it should be thoroughly soaped. With the trial plate it is then placed in proper position, and plaster mixed quite thin is added to the original model from the posterior end.

When removed the model resulting gives a perfect representation of the teeth and soft tissues supported by bone; of the cleft palate as it is when normally at rest and of the pharynx when closed as in the act of swallowing. It is from such a model that I make my modified Kingsley velum, which is really in its action what Dr. Case calls a velum obturator.

THE MAKING OF ARTIFICIAL VELA.

With an accurate model from which to work an artificial velum could be made without further reference to the patient, though it might be best for the inexperienced to try in the model of the velum before proceeding to the construction of metal molds.

The first step in the production of the Kingsley velum will be to make a model of the palatal flap. The model of the velum, if it is not to be tried in the mouth, may be made of wax, otherwise it will be best to use sheet gutta-percha. The palatal flap is a triangle with rounded angles. The apex of this triangle coincides with the apex of the fissure, and the base extends across from one uvula to the other. This flap should be made just large enough to bridge the gap, as it will be easy to widen it later by scraping the mold should it become needful, whereas if made too large at the outset, it might become necessary to make

a part of the mold over. The pattern of the flap having been cut out from gutta-percha, it is to be slightly softened and then pressed against the model, so that it assumes the proper form to lie close to the surface of the latter. It will often occur that the edges of the natural cleft are rounded or rope-like, thus showing a depression between the border of the cleft and the maxillary bone. In these cases the upper flap, when molded upon the model, will assume quite a curl or crimp, especially near the uvulæ. If the model is accurate and the flap is made to properly conform to this peculiarity, when placed in the mouth it will lie close against the soft tissues. Were it left comparatively a plane, the edges would stand off and be quite noticeable to the tongue. This curling is made more apparent because of the fact that the flap is slightly depressed between the sides of the cleft, so that it forms a part of the arch of the mouth and completes it. As soon as the flap has been molded into proper form, all the edges being quite thin, it is plunged into cold water, so that it shall retain its shape.

FIG. 881

The second or upper flap is molded upon the model in a similar manner, the form being again triangular. But the base must now be fashioned so that its posterior edge will meet the ridge of the pharynx

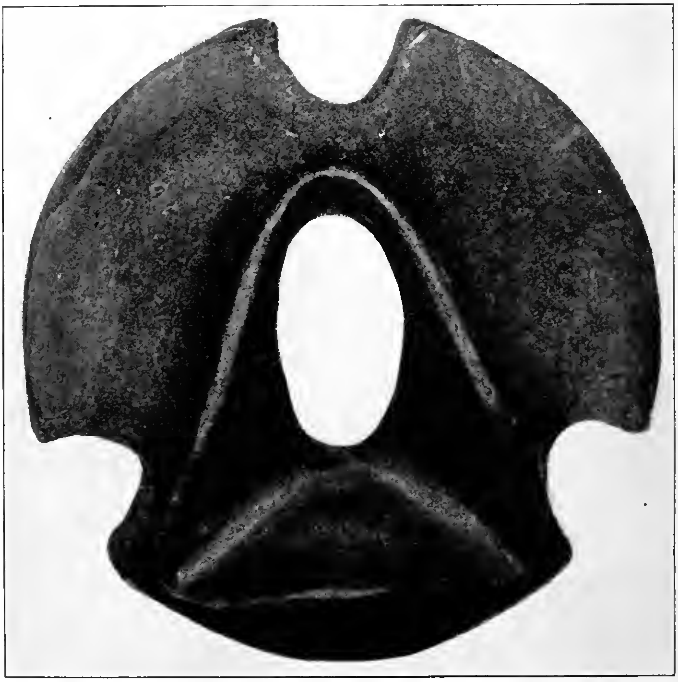
at a slight angle. The general adaptation of the flap to the model having been obtained, it is placed in position, and the model and flap firmly held in the left hand, while with the thumb and forefinger of the right hand the operator grasps the flap at the centre of the posterior part and simply bends it up, whereupon it assumes the form shown in Figs. 845–847. Usually the guide for bending this tail-piece is to form a margin so that the plane of that surface will be on a line with the incising edges of the anterior teeth.

The two flaps are next placed upon the model at the same time and waxed together with hard wax. The velum is then ready to be tried in the mouth, when the operator may correct any discrepancies as to fit in length.

The model of the velum having been satisfactorily made, it becomes necessary to produce metal molds in which soft rubber may be vulcanized into the desired form.

A convenient form of flask for holding these molds is round and in two parts, one of which has a square hole cut at the centre.

FIG. 882



In constructing the molds the model of the velum is placed in that half of the flask which has the hole, so that the smaller or palatal flap rests over the hole. The flask having been freely oiled, plaster is poured into it and around the model. When hard it is knocked out readily and carved into shape. It is then varnished, replaced in the flask, and

oiled. The model of the velum still being in position, plaster is poured over it and the plaster mold which now surrounds it, and the opposite half of the flask, well oiled, is put on and pressed firmly to place. When this is hard and separated the two parts of the mold are complete. The third is made by pouring plaster through the hole in the top of the flask, completely filling the space left within the flask, and covering the top flap. These three pieces of plaster are then reproduced by molding in sand and casting in type-metal. The general appearance when complete is shown in the accompanying illustrations. Fig. 881 is the bottom-piece, in which a pin appears; this is best made of iridio-platinum wire, and is driven into a drilled hole after the model

Fig. 883

is cast. In some cases it will be tight enough, but occasionally it may be requisite to fasten it with soft solder. Its purpose is to produce a hole in the velum through which the bar on the plate passes. The two aspects of the central piece of the mold are shown in Figs. 882 and 883, while Fig. 884 shows the top-piece. The surfaces for molding the rubber are to be smoothed with a pine stick and pumice. The metal molds are returned to their respective positions in the flask sections.

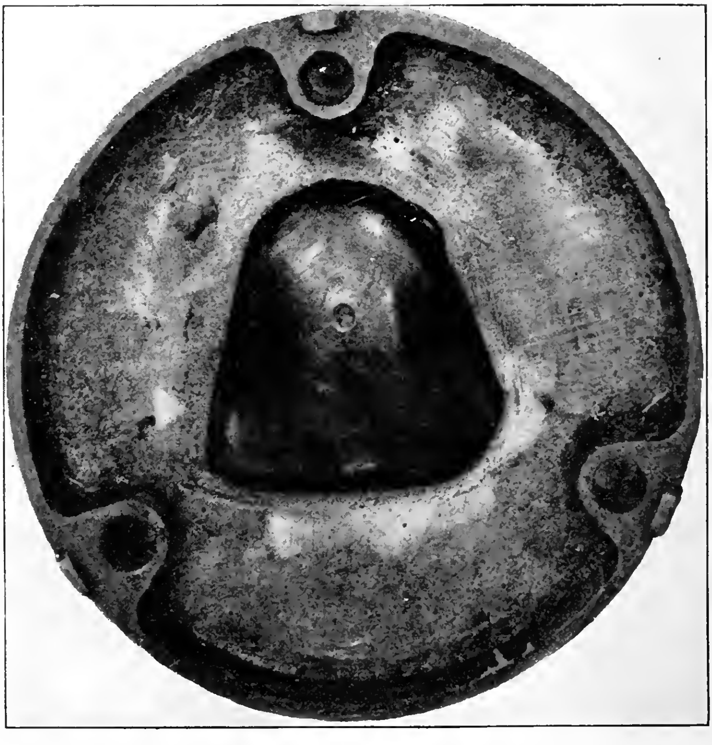
In vulcanizing the soft rubber it is well to slightly soap the surface of the molds before packing, as this facilitates removal after vulcanization, and avoids a tendency on the part of the rubber to adhere to the

metal, especially should any rough places be left, which of course should be avoided.

The flask should be opened and excess of rubber removed; otherwise it will be pressed against the unpolished portions of the mold, and render it extremely difficult to open the flask after vulcanization. As soft rubber swells considerably during vulcanization, the mold need not be quite full, but care should be taken to avoid creases in the rubber, as they will not be filled out however much the rubber may swell, probably owing to the imprisonment of air.

The best results in the vulcanization of soft rubber are obtained by observing the following directions: Place charcoal or other substance in the bottom of the vulcanizer high enough to stand above the water which is poured in. Allow the flask to rest upon this charcoal. In this manner the rubber is vulcanized in steam.

FIG. 884



The thermometer which registers the heat should indicate 240° for two hours; 250° for one hour; 260° for one hour; and 270° for one hour.

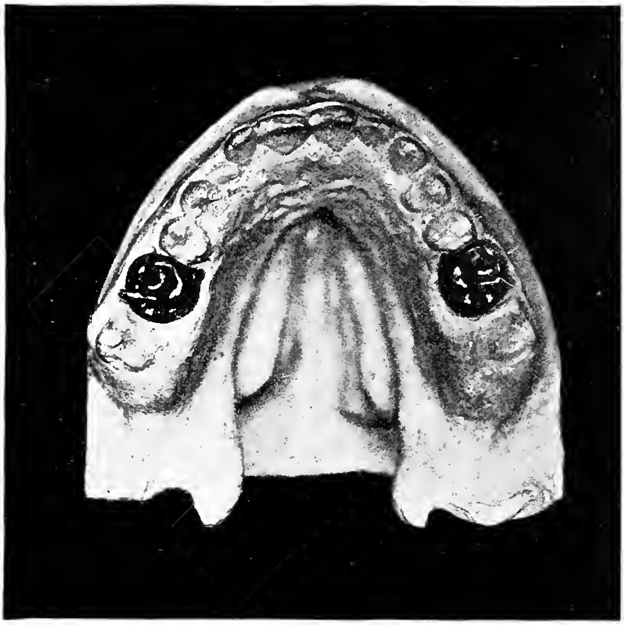
The velum when taken from the flask will have a peculiar odor if overdone, as though it had been burned. In that case, however perfect and elastic it may appear, it will be worthless within a very few weeks.

THE CONSTRUCTION OF AN OBTURATOR.

An obturator may be made for a patient where the cleft involves the soft palate only, but will be more commonly resorted to where both soft and hard palates are fissured. The process in connection with the latter condition is described, as it is the more intricate.

A correct model having been obtained, the fissure in the hard palate is filled with wax, so that the arch of the vault is restored. Dies are made and a plate of iridio-platinum swaged to fit this reconstructed model, with the result, of course, that when carried to the mouth it

Fig. 885



bridges over the gap in the hard palate. The plate is provided with an extension at the posterior part which shall support the obturator, and it is attached to the teeth by gold clasps. For this purpose it is best to rely upon the sixth-year molars as offering the best anchorage, and where these teeth are badly decayed it is often advisable to crown them with gold before fitting the clasps about them. Thus the anchorages may be permanently protected against loss by decay.

Where crowns are used it will be found most advantageous to use the clasp invented by Dr. Emory A. Bryant, as this deviee not only holds a plate firmly in place but prevents tilting during the action of swallowing. To construct a clasp of this character, after the crowns are made they are loosely fitted over the natural teeth or roots which they are to cover, and an impression taken, which of course removes them when

withdrawn from the mouth. Plugs of pine wood are fitted with moderate accuracy into the crowns slightly protruding therefrom, and the model is then poured. By this precaution the crowns are easily removed and replaced upon the model. With any of the many paralleling devices, parallel lines are scratched on the buccal surfaces of the gold crowns, and along each line is soldered a piece of iridio-platinum wire. The clasp is made of clasp material of 26 gauge. The end is bent to fit around the wire attached to the crown, and the clasp then bent to follow the circumference of the crown as far as the mesio-palatal angle. This end of the clasp is then bent in similar fashion, and a piece of iridio-platinum wire slipped between the clasp and the crown. The tiniest drop of solder is now fused to hold the wire and crown to-

Fig. 886

gether, and the clasp is then removed and the wire firmly attached to the crown with more solder. The clasp thus fitted is then stiffened by flowing solder over its outer surfaces. The clasps are attached to the plate in the usual manner. Fig. 885 shows an artificial palate with gold crowns in place and (Fig. 886) a plate with clasps of this nature. The plate in this illustration carries a Kingsley velum, but the plate for an obturator would be essentially the same except that its posterior edge would be angular to fit into the palatal surface of the hard rubber obturator (see Figs. 887 and 889), which prevents lateral movement of the obturator when bolted to the carrying plate.

The metal plate and clasps having been accurately fitted to the mouth, a loop of copper wire is soldered temporarily to the upper side of the plate (with soft solder) and extended backward about two-thirds the length of the fissure. The object of this is to hold a mass of impression material which is to be used for forming the model of the obturator. This mass of impression material is wrapped about the wire loop and

then fashioned into the general shape of the fissure, when it is hardened in cold water. A trial in the mouth will indicate wherein it must be altered by trimming with a sharp knife. The mass having been brought to an approximation of the proper form after this manner, it is then slightly softened in warm water and again placed in the mouth, whereupon the patient is directed to swallow several times. This compels the levator and constrictor muscles to close upon the softened mass and mold it into such shape as will be required to enable the patient to completely close the opening to the nares. Upon removal the mass will have assumed an irregular shape, which now must be altered to furnish the final model of the obturator. The palatal surface is trimmed into a continuous flat surface, so that in connection with the plate the arch of the vault is completed and the gap in the back of the mouth bridged over. The upper surface is similarly cut away, and is usually best formed with a depression curved laterally, experience having taught that such a form is best adapted for the obliteration of the nasal quality of the voice. Thus the sides and the posterior end are left undisturbed as they were molded by the action of the muscles.

FIG. 887

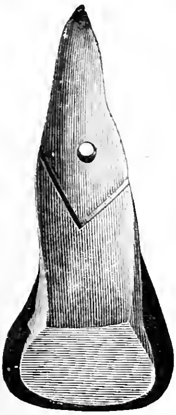


FIG. 888

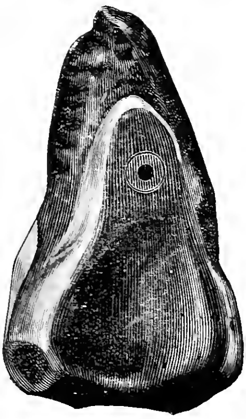
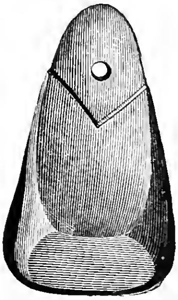


FIG. 889



It must be remembered that no matter how yielding the mass may have been, it is also sufficiently resistant to have prevented the muscles from closing to their utmost limits. It is therefore necessary to trim these surfaces so as to still further reduce the size of the bulb, especially at the posterior end, where the ridge of the pharynx is expected to touch it. In the region of the uvulæ the side must be trimmed away so that they may close under the obturator, and to this end that part of the bulb may be narrowed at the lower and widened at the upper side, thus producing inclined planes against which the levators will play and be in contact at all times during their contractions. In the region of the uvulæ the bulb may be cut away on a line with the bases of the uvulæ, so that the surface produced will be a plane which if extended by an imaginary line would reach the incisive edges of the anterior teeth.

Figs. 887–889 are introduced to show the great variations in the forms of the bulbs, the size and shape being dependent upon the peculiarities of the fissures and activity of the throat muscles. In Figs. 887 and 889, *a* indicates the flat surface where, as has been described, the bulb is cut away near the bases of the uvulæ, while *b*, *b* show the slanting sides against which the levators play. Fig. 888 shows the nasal surface of a large obturator, and along the centre is seen the depression, which, experience has taught, is serviceable in many cases in correcting the nasal quality of the voice usually present. Upon the upper surface the depression alluded to is seen at *c*, but it must be borne in mind that this is not always a necessity, being less so in small obturators (as in Figs. 887 and 889) than in large.

The model having been brought to this point, plaster is mixed as for an impression, and a little placed upon the upper side of the plate, extended from where the impression material ends sufficiently forward to reach the anterior end of the fissure when placed in the mouth. The plate, with plaster upon it, is then quickly carried into place, and upon removal the plaster will have taken an impression of the forward part of the cleft. It is cut away to a level with the upper side of the impression material, and with it completes the model of the obturator, which must now be reproduced in hard rubber.

Plaster molds are next made in which to reproduce the bulb in hard rubber, and when flasked and ready for packing the bulb is made as follows: Patterns of the upper and under surfaces are cut from thick tin-foil, and a single pattern to extend around the sides and end. These are similarly cut from sheet rubber, and are united in the general form of the bulb by placing the edges together and pinching them fast with a pair of tweezers. Before finally closing, water should be introduced filling the bulb about three-quarters full, great care being observed lest the edges of the rubber should become wet, which would prevent perfect union and allow an escape of steam during vulcanization, the result being a collapse of the bulb. If these steps are accurately taken and the flask tightly closed, the bulb will be thoroughly well filled out and will be a perfect reproduction of the model.

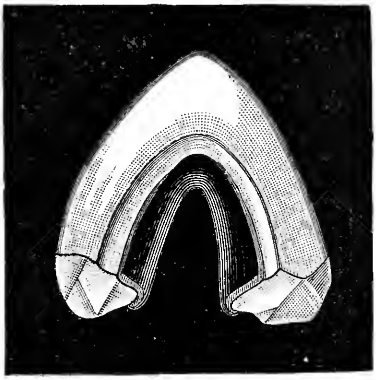
The bulb is next to be fitted to the plate, the proper position being determined by models which were taken while the plate and wax (impression material) model were united. A hole is then drilled through the bulb and plate, through which an iridio-platinum bar is passed and soldered to the plate, the opposite end being screw cut and supplied with a nut. The hole drilled through the bulb for the passage of the bar also serves for the removal of the water used in vulcanizing. The surface of the plate over which the bulb is to lie is smeared with gutta-percha, the bulb slipped over the bar, and the nut turned down until it impinges. Then by warming the plate over a Bunsen burner the gutta-percha is softened and the nut screwed down, driving the obturator tight against the plate, the gutta-percha serving to form a water-tight joint. The plate and bulb are then polished and are ready for the patient.

DR. CASE'S VELUM OBTURATOR.

Dr. Case describes his method as follows:

The model of the body of the palate, as shown in Fig. 890, is formed first, and then inserted in the mouth for trial. This can usually be accomplished with the hand alone, by passing it back of its proper position and then bringing it forward. It should be done quickly and easily, or contraction of the muscles will prevent its accomplishment.

FIG. 890



At this time the lateral nasal extensions of the model should be abridged to facilitate introduction. They can be added at the time of investment and still further extended, as can other parts, by scraping the metal casts.

FIG. 891

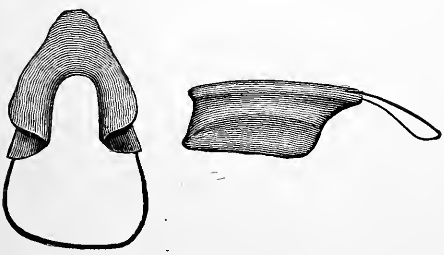
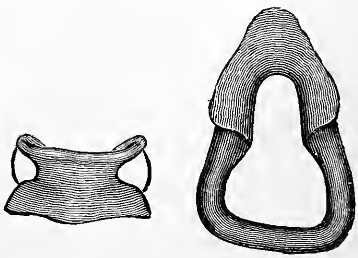


FIG. 892



The surface of the pharyngeal wall in the contracted position of its muscles, which represents the surface that is ultimately to close around and press against the peripheral border of the artificial veil, is obtained with a loop of No. 22 soft copper wire, the free ends of which pass into tubes imbedded in the upper surface of the model, as shown in Fig. 891.

The loop is drawn out and bent to about the proper size and shape, and the model then inserted in the mouth for correction. This is re-

peated, bending, enlarging or contracting, etc., until the wire is seen to rest along surfaces that are best adapted to unite in their action with the artificial veil for the ultimate closure of the naso-pharyngeal opening.

The posterior line of wire should rest just in front of or slightly above the greatest contracted extension of the superior pharyngeal muscle. The surrounding muscles can be made to contract by a slight titillation of the surface, and what is of the greatest advantage—the pharyngeal walls above and below the wire can be readily seen and studied in their action through the open loop.

The action of the muscles alone, springing forward against the pliable wire loop, pressing it back into it sockets, or bending it to fit their surfaces, will frequently cause it to mark the desired peripheral outline of the artificial velum.

As the loop turns forward to pass beneath the openings of the Eustachian tubes, the pharyngeal surfaces will often be found corrugated and thrown into irregular folds, so that in finding the smoother path across these ridges to prevent the escape of air at the border of the veil through the sulci it may be found desirable to raise or lower the wire upon one side more than the other. Forward of this it soon comes in contact with the upper surfaces of the palatal muscles as it enters the posterior nares.

After fitting the wire, to mark the desired outlines of the veil, the roll of compound which is to form the model of the border of the veil may now be attached to the loop, following the outline of its peripheral surface, and finally adjusted to the mouth to correct imperfections.

Fig. 892 shows different views of a model and completed palate.

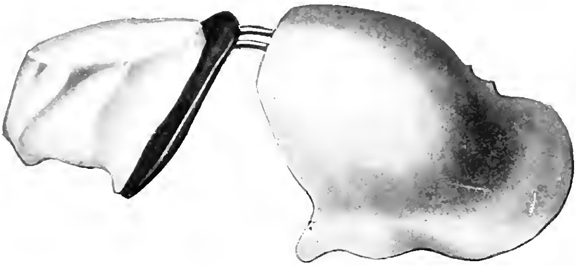
THE AUTHOR'S VELUM-OBTURATOR.

An analysis of the following description of the construction of my own "velum-obturator" will disclose that it is exactly what its name implies, and that the method of producing it is but a combination of the technique already described for soft rubber vela, and for hard rubber obturators. In obtaining a wax model for the hard rubber obturator, it will be recalled that we first made the metal carrying plate, soldered a loop of copper wire temporarily to the upper surface thereof, molded composition about this wire loop and obtained an impression of the pharyngeal region by introducing this into the mouth with the composition soft, and then having the patient swallow. (See pages 826, 827.) This compound impression was then itself used as the model for the hard rubber obturator, with certain alteration in shape, which have been already described. In constructing a soft-rubber velum-obturator the technique differs slightly, as it is advisable to produce a plaster model of the parts: one which, as already insisted upon, will show the anterior position of the mouth at rest, and the posterior or pharyngeal region closed.

In the first case treated by me, after obtaining the plaster model in the usual manner, I then fashioned a trial plate of gutta percha, using two thicknesses to afford greater stability. Between the two layers, I

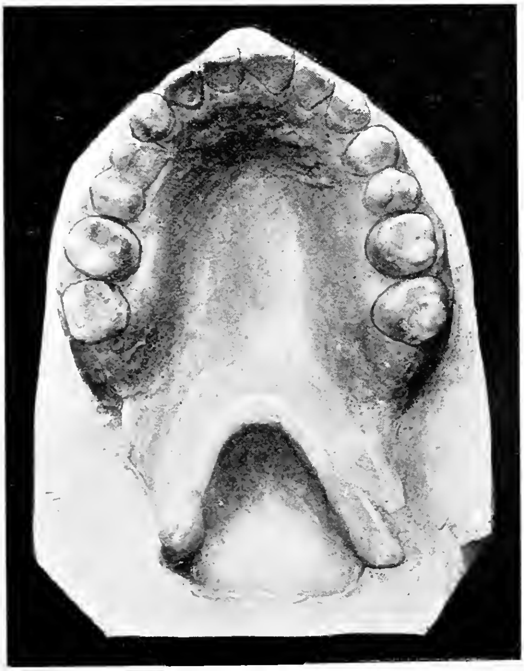
placed the ends of a copper wire loop, this loop entending backward and being bent to follow the curve of the palate. This gave me a trial plate similar to the metal plate used in this part of the technique of making a hard rubber obturator.

Fig 893



It is not absolutely essential to have this wire loop, but it is an added safeguard against dislodgement of the wax which is to be used for taking the impression of the throat, and leaves the operator fairly certain that the patient will not swallow the mass of wax, an accident not at all impossible.

Fig. 894



In the case under description, the cleft in the palate was so far back that the copper wire was also a convenience in spanning the gap between the posterior border of the hard palate and the anterior border of the cleft. (See Figs. 893 and 894.) The wire loop was then wrapped

with a mass of ordinary beeswax and formed into a mass approximately a little too large for the cleft. This was then softened in warm water, introduced to place and held in the mouth with the forefinger while the patient was instructed to swallow repeatedly. When removed, this wax afforded an approximate, not an accurate, impression of the pharynx when closed. It might be accurate, and it might not, depending upon the strength of the parts to compress the wax fully. However, an approximate impression is all that is needed at this stage. Next a considerable portion of the surface of the wax is cut away, and so cut that the surface is left quite rough. It must also be trimmed away sufficiently so that when introduced, and the patient is allowed to swallow, he will report that he does not feel it.

This wax mass is then covered with a layer of creamy, quick setting plaster of Paris, is placed in the mouth and the patient again asked to swallow repeatedly. There is no danger that the plaster will drip down the throat unless altogether too much plaster be used. Indeed, in handling plaster in the mouth an excess should never be introduced. However, as an additional precaution, the operator may have at hand two or three swabs, made by wrapping cotton around the end of sticks of orange wood. With these swabs *dry*, if any plaster should be seen to trickle downward, it can be quickly and deftly wiped away.

Fig. 893 shows the trial plate removed with the plaster impression of the pharyngeal opening which is left by the contraction of the muscles. This gutta-percha plate, having been accurately made on the already constructed model is readily replaced thereon, and the impression of the pharyngeal region will extend back beyond it. The plaster used in taking this impression should be slightly colored by adding paint powder to the mixing water, or else it should be thoroughly varnished with shellac, followed by sandarac. The trial plate carrying the impression, having been placed on the model, additional plaster is added to the posterior part of the model so as to completely surround the impression. Later, when thoroughly hard and the impression was removed the result was the model seen in Fig. 894, which shows the hard and soft palatal regions *at rest*, and the pharyngeal muscles *contracted*.

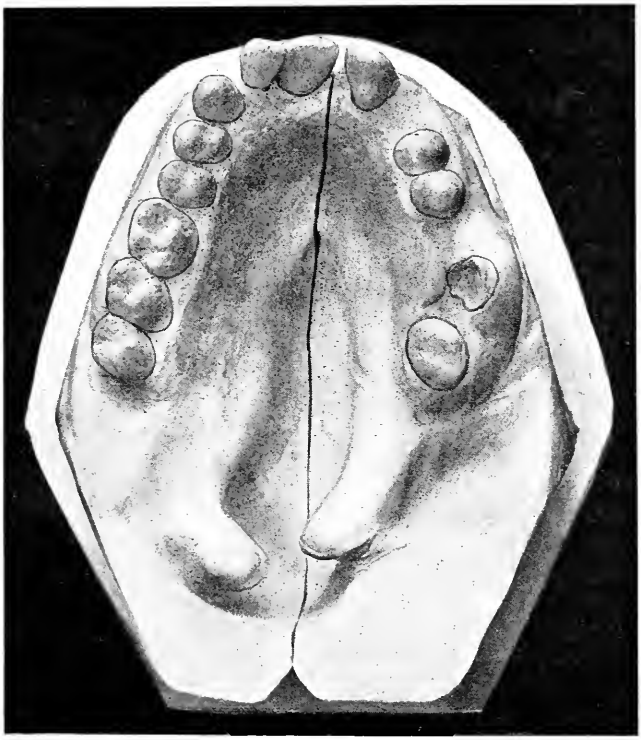
On this plaster model, a wax model of the velum-obturator is formed, having secured which, metal molds are made from the wax model exactly as has been described for making a Kingsley soft velum. The velum-obturator made for my first case is seen in Fig. 867 attached to its metal carrying plate. In Fig. 893 it will be observed that there is a flat or plane surface on the top of the plaster impression. This, of course, is not as it would be when removed from the mouth, but it has been so trimmed, for comparison with the velum-obturator seen in Fig. 891.

In the main there may be said to be three classes of cleft palate cases which may come in for treatment. Those in which the cleft is in the soft palate only (Fig. 894); those in which the hard palate is also involved (Fig. 895); and those resulting from failures of surgeons (Fig. 899.)

I am glad to say that thus far I have been successful with my new instrument in all three conditions.

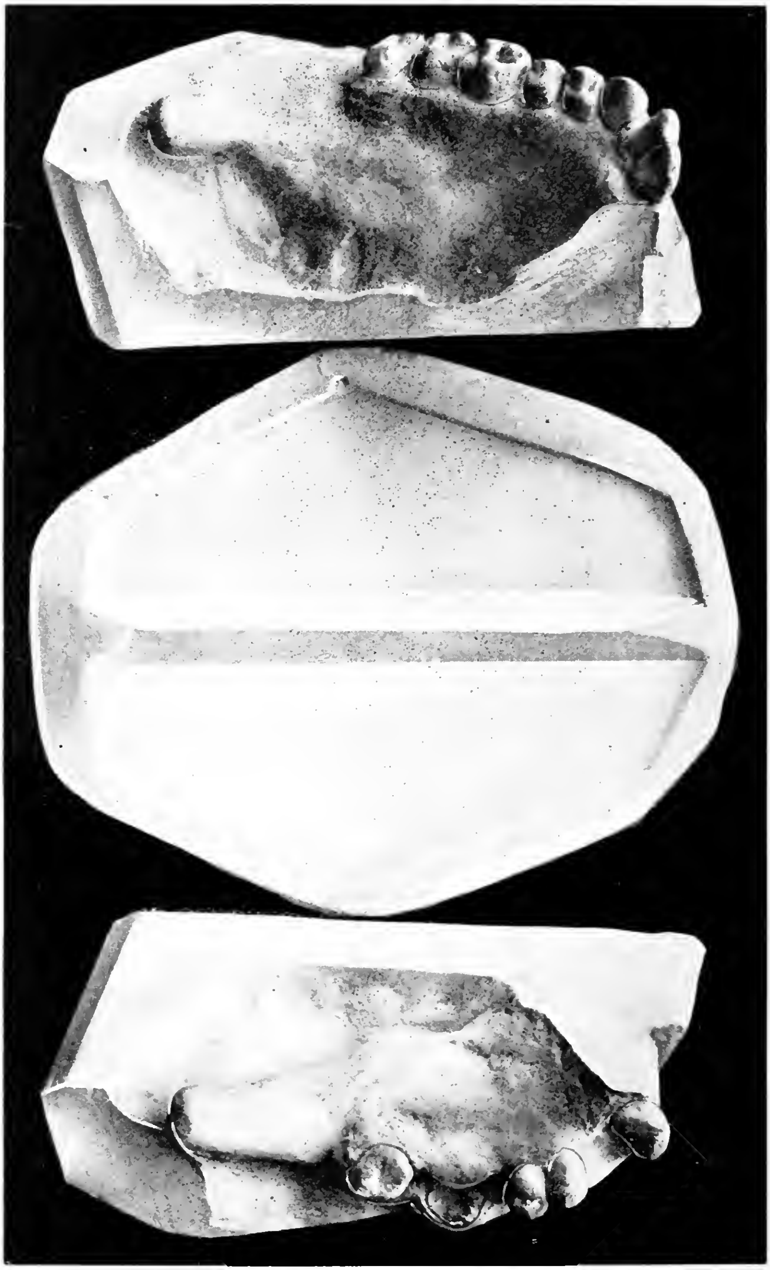
I have said that the wax model of the velum-obturator is made directly on the model, and then removed and used in forming the metal molds in which the soft rubber is to be vulcanized. But sometimes the removal of the wax model would be impossible with the model entire. Such a condition is shown in Fig. 895, where the plaster reproductions of the split uvulæ would hinder the removal of the wax. It is therefore advisable to split the model in half, but at the same time means must be provided for accurately reassembling the two halves of the model. I, therefore, carve a V-shaped groove in the under side of the model, and pour a base or stand to receive it. I saw the model almost through, and

Fig. 895



then forcibly break it into two parts. This is better than sawing it entirely through, as the fractured edges will co-apt more closely when reassembled. Fig. 896 shows the model split in two and the base, and Fig. 897 shows a side view of the model reassembled and held together by the base in which it is set. This division of the model not only facilitates the forming of the wax model of the velum-obturator, but also affords a guide for trimming away the upper or nasal surface, as is seen in Fig. 867, and again in Fig. 898, which is the velum-obturator made for the case shown in Figs, 895, 896, and 897. It is not advisable that these instruments should be made too thick. The usual method is to leave a

FIG. 896

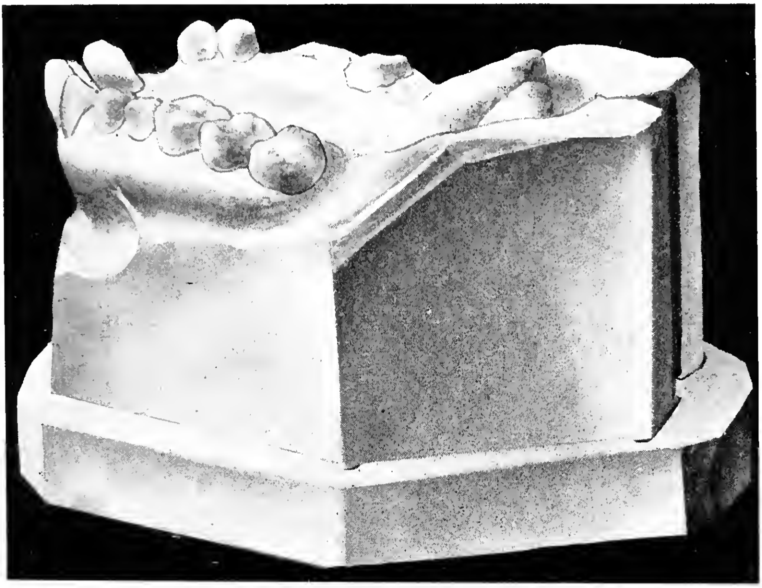


good broad surface for posterior and lateral contact, and then cut away the plane to a level with the upper surface of the carrying plate. (See Fig.

867.) Having the model divided enables the operator to place the wax model in position in one-half, and thus study the space which it is desirable to leave when cutting away the upper surface of the wax.

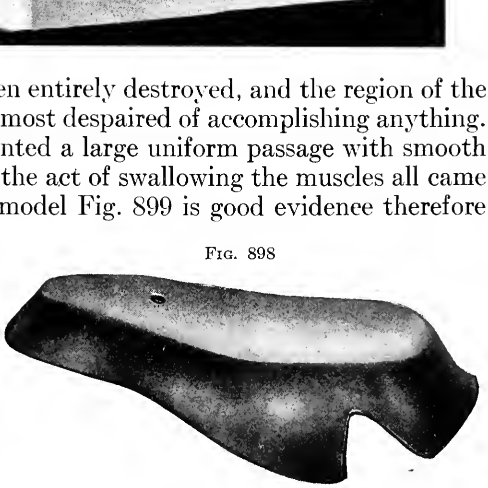
In Fig. 899 we see the model of a case which resulted from a surgical failure. The cleft in the palate has been partly bridged with inelastic

Fig. 897



scar tissue, the uvulæ have been entirely destroyed, and the region of the pharynx so mutilated that I almost despaired of accomplishing anything. The throat when at rest presented a large uniform passage with smooth walls, but when contracted in the act of swallowing the muscles all came into conspicuous view. The model Fig. 899 is good evidence therefore that it is made from an impression of the parts when constricted. For this patient I made the velum-obturator shown in Fig. 900. I utilized the small aperture in the centre of the palate as a point at which to thicken the rubber sufficiently to close the aperture

Fig. 898

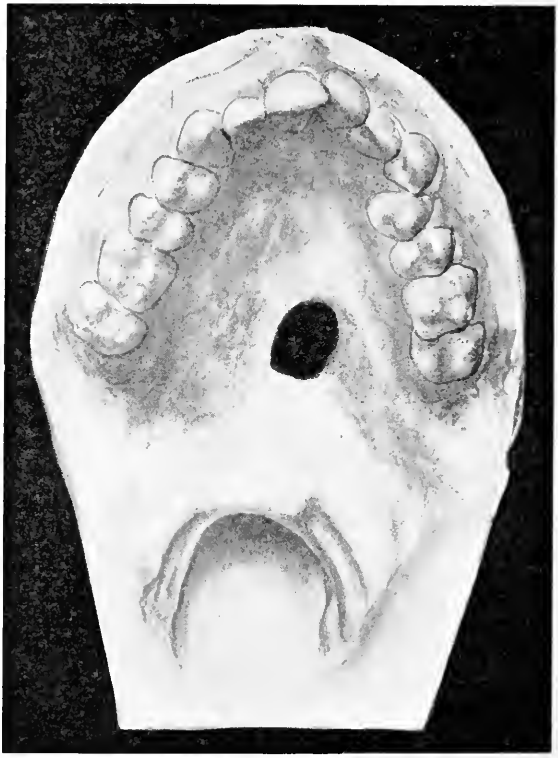


and at the same time to grasp the post, which is always placed on the upper side of the metal carrying plate, and over which the soft rubber part buttons. We then observe (Fig. 900) a stretch of rubber formed to overlay the surgical bridge in the soft parts; this was made just thick enough to afford stability, but was further supported by an extension from the carrying plate. At the posterior part of the illus-

tration is seen a bulbous mass, which is made to exactly conform to the aperture left by the closure of the pharynx.

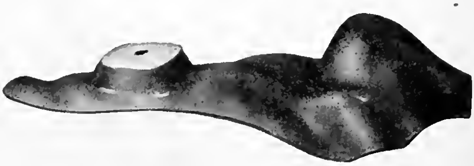
This instrument was largely experimental, but it is pleasant to report the result. The young man improved so much that he conceived the

Fig. 899



purpose of studying dentistry, partly with the idea of some day helping others suffering with like deformity. When I learned this, and that he was already at a dental school, I cheerfully presented him with the metal molds, and he now makes his own duplicates.

Fig. 900



There is one advantage of this velum-obturator which is worth recording. Being made in larger masses than the Kingsley velum the soft rubber is not so quickly destroyed by the fluids of the mouth, nor is it distorted by curling up. It therefore requires renewal less frequently.

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